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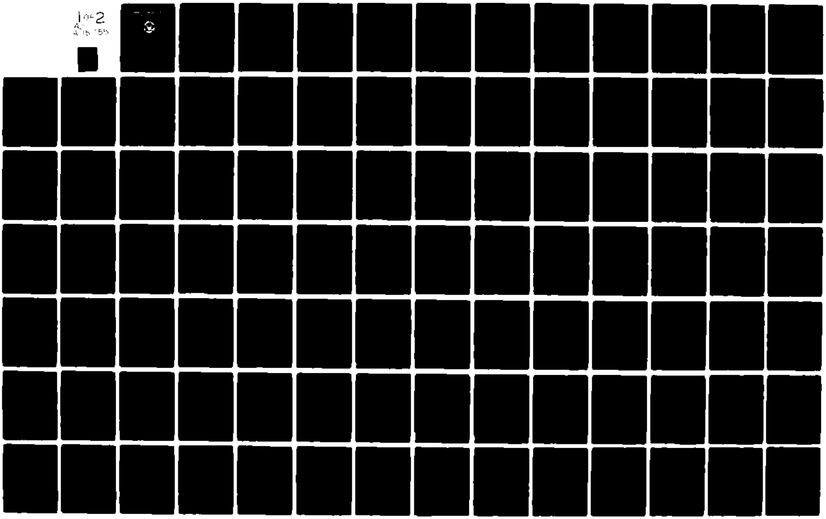

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

ANALYSIS OF THE RELIABLE STING
EARLY WARNING SYSTEM

by

Robert John Reese

March 1982

Thesis Advisors: S.H. Parry
J. E. Ellis

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The U.S. Army is attempting to standardize short-range air defense command and control procedures. The Reliable STING Early Warning System has been selected as one of the models for this standardization. This thesis analyzes the Reliable STING concept to determine the degree to which it satisfies the users' requirements for air defense command and control information and to determine potential enhancements to increase the effectiveness of its early warning capabilities. Analysis is based

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Analysis of the Reliable STING Early Warning System

by

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Captain, United States Army
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Submitted in partial fulfillment of the requirements for the degree of

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The U.S. Army is attempting to standardize short-range air defense command and control procedures. The Reliable STING Early Warning System has been selected as one of the models for this standardization. This thesis analyzes the Reliable STING concept to determine the degree to which it satisfies the users' requirements for air defense command and control information and to determine potential enhancements to increase the effectiveness of its early warning capabilities. Analysis is based upon an identification of the users and a determination of their air defense information requirements. The system's ability to apply the potential value of information resources, to satisfy these needs, is the measure of its effectiveness. Proposed alternatives are directed at providing near-term, low-risk solutions to identified deficiencies.

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I. INTRODUCTION

A. BACKGROUND

The U.S. Army is presently undergoing tremendous change. This change is evident in the new equipment being developed and fielded, in new doctrine and tactics designed to take full advantage of equipment capabilities, and in new force structure that maximizes the effectiveness of that doctrine and tactics. The focus of this change is the division, with the greatest emphasis on the armored and mechanized divisions.

Some of the most significant changes are aimed at the division air defense. These improvements are directed at correcting two major deficiencies:

- o Insufficient numbers of air defense weapons to adequately defend the division from air attack.
- o Inadequate command, control, and communications (C3) to effectively employ these short range air defense (SHORAD)[1] assets.

Field Manual 100-5 states that,

> No modern army can expect to win in battle unless its maneuver forces operate under a cohesive, extensive, mobile umbrella of modern air defense. [Ref. 1]

----

[1]Two terms are generally used to identify divisional air defense assets: SHORAD and MANPAD. MANPAD (Man Portable Air Defense) refers to Redeye and Stinger. SHORAD identifies the remainder of the short-range weapons: Vulcan and Chaparral. For the purpose of this thesis, the term SHORAD will be used to identify all of the divisional AD assets.

1. <u>Insufficient Numbers</u>

There are many programs directed at providing more extensive, mobile, and modern air defense. Stinger, Patriot, DIVAD Gun, Roland, and others concentrate on correcting the first deficiency by providing higher quality systems to be deployed in support of the division. Unfortunately, the improved lethality and additional weapon systems, combined with the growing number of aircraft operating over the division, increases the demands placed upon existing SHORAD command and control procedures. Until a C3 system capable of maximizing the effectiveness of the new weapon systems is deployed, the goal of cohesive SHORAD air defense will be remain elusive.

2. <u>Inadequate Command, Control, and Communications</u>

This lack of effective C3 has a negative impact upon a SHORAD fire units's ability to engage aircraft. To date, fire units have been forced to depend upon:

- o Visual search and recognition procedures.
- o Manually transmitted command and control and long-range early warning information.
- o Limited short-range early warning from a single source.

These factors combine to limit the effectiveness of SHORAD assets.

The Army's development of the SHORAD Command and Control (SHORAD-C2) System represents an attempt to correct this C3 problem. With initial operational capability planned for 1990+, deployment of this system will follow the majority of the new weapons presently under development. As a result, an interim solution to the SHORAD C3 problem is needed. The Army intends to meet this need with the Manual SHORAD Control System (MSCS). The concept for the MSCS, which was published in the latest change to the Army's SHORAD field manuals, represents an attempt to standardize the approach to SHORAD command and control. [Ref. 2]

The Manual SHORAD Control System is intended to be an evolutionary system. Development will progress through three stages en route to the fielding of the automated SHORAD-C2 System. The first stage, the basic MSCS, utilizes existing SHORAD assets. The second stage, an improved MSCS (IMSCS), is designed to increase the operational capability of the basic system by adding improved high frequency radios. The third stage combines additional equipment, personnel, and procedures to produce an enhanced version of the system (EMSCS). [Ref. 3]

The enhanced MSCS will be patterned after the Reliable Swift Target Identification Notification Grid (STING) System developed by the 9th Infantry Division (ID), at Ft. Lewis, Washington. Supporters of Reliable STING believe that it offers the best manual solution to the SHORAD early warning/command and control problem. Reliable STING's capabilities, which extend far beyond early warning, were demonstrated during REFORGER '81 in a test to compare it with the basic MSCS.

B. PURPOSE

This thesis will examine the Reliable STING concept to determine:

- The degree to which Reliable STING satisfies the users' requirements for command and control information, with emphasis on early warning information.
- Potential enhancements to increase the effectiveness of Reliable STING's early warning capabilities.

C. APPROACH

Although Reliable STING provides information to a variety of elements ranging from the division staff to deployed maneuver units, this study will focus on the air defense information needs of the SHORAD fire units. The performance of the Reliable STING Early Warning System will be evaluated in terms of its impact upon fire unit effectiveness.

Chapter II will provide the reader with a description of the Reliable STING concept. This description is intended as background information and will not include any analysis. The third chapter will build upon the description of Reliable STING by identifying the system's users and their air defense information requirements.

Chapter IV examines the information resources available to a SHORAD early warning/command and control system. The information provided by these resources will be compared to the users' requirements to determine its potential value. The fifth chapter will then analyze the value of air defense information provided to the user by Reliable STING, again in terms of the users' information requirements.

Chapter VI will compare the results of the two previous chapters to identify any elements of air defense information whose value is either improved or degraded by system processing. The processing performed by the system will then be examined to determine the functions responsible for any change in information value. Enhancements, directed at providing near-term, low-risk solutions to identified deficiencies, will be proposed.

II. RELIABLE STING DESCRIPTION

In 1977 the commander of the 9th Infantry Division instructed his air defense officer, the commander of the SHORAD battalion, to improve the division's air defense capabilities. Four major deficiencies were identified:

- Inadequate air defense artillery coverage.
- The lack of an early warning system.
- The lack of an effective division airspace management system.
- Unrealistic air defense training scenarios. [Ref. 4]

Many ideas were explored and numerous concepts were examined. The most prosperous of these concepts, Reliable STING, addressed the second deficiency noted above, the lack of an early warning system.

Reliable STING has been reported as having exceeded the goal of providing early warning information. It attempts to accomplish four objectives:

- Provide SHORAD and other divisional units rapid air defense early warning information.
- Improve the airspace management through close coordination with the division airspace management element (DAME).
- Provide air defense warnings, rules of engagement, and special weapons control measures to SHORAD and other divisional units.
- Provide SHORAD and other divisional units with emergency alert information (NBC warnings, enemy airmobile operations, etc.).

To meet these objectives, a combat information system was created (see Figure 1). Reliable STING links anti-aircraft search radar, airspace management/flight coordination elements, and air defense headquarters to provide the inputs required by this information system. These inputs are then processed by the information center. Air defense information is provided as output to the users over a division broadcast network. The users are those divisional elements that desire information concerning the air battle.

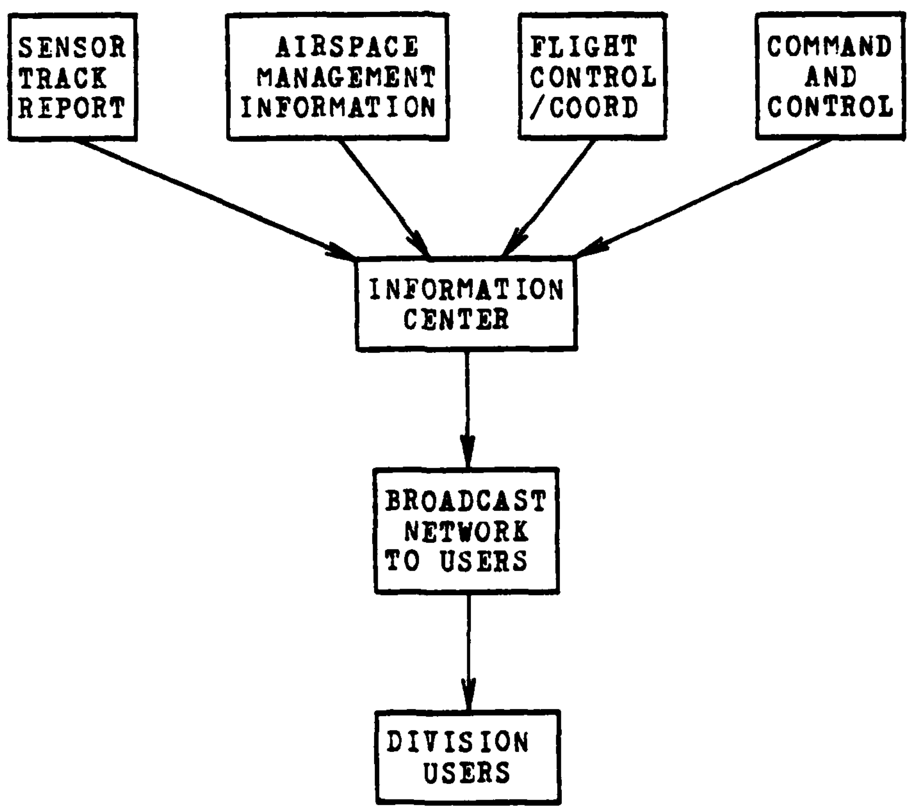


Figure 1. Reliable STING Early Warning System

A. SENSORS

Reliable STING's early warning function requires timely data concerning aircraft flights over the division area. That information, in the form of target data (track reports), is provided by four sources:

- o Forward Area Alerting Radar (FAAR).
- o High-to-medium-altitude air defense (HIMAD - Hawk for the 9th ID) or Air Force Forward Air Control Point (FACP) radar.
- o Air Force Airborne Early Warning and Control System (AWACS).
- o Visual sightings by friendly aviation elements.

Each of these information sources along with its input are discussed below.

1. Forward Area Alerting Radar

Eight FAAR sections are organic to a division SHORAD battalion. Organized into one radar platoon, these sections provide short-range early warning information. The sections are deployed to provide effective coverage of the division area and to supplement Hawk radar coverage. Under the Reliable STING concept only four of the FAAR sections are operated at any time. These four active sections pass track reports directly to the information center, the Air Battle Management Operations Center (ABMOC), using standard radio (voice) transmissions. The FAAR sections originate the majority of the reports which are processed by the system. ABMOC personnel control the positioning and operation of the FAAR sections.

2. HIMAD/Air Force Radar

Information concerning long-range tracks is provided by the Hawk battalion that supports the division (doctrinally divisions receive direct support from a Hawk battalion assigned to the air defense organization in support of corps) or by the nearest Air Force control facility. This is accomplished by an Air Defense Coordination Section from the SHORAD battalion (ADCS - one officer, one NCO, and three enlisted) which is deployed to the Hawk unit or to an Air Force Forward Area Control Point (FACP), Control and Reporting Point (CRP), or Control and Reporting Center (CRC), when Hawk is not available. Air Force target information is received by the Hawk battalion over the AN/TSQ-73 Missile Minder System (a C2 system connecting HIMAD units to the nearest Air Force CRC).

3. Airborne Early Warning and Control System

Long-range track information can also be provided by AWACS. Deployed prior to the positioning of FACP's or to extend coverage beyond their limits, these aircraft can provide excellent long-range early warning. The 9th ID has received direct support from AWACS aircraft during field training exercises.

4. Friendly Aviation

The division's Flight Coordination Center (FCC) is the fourth source of track information. Aircraft flying missions in support of the division maintain contact with the (FCC). An operations cell from the FCC deploys with the ABMOC. This cell provides critical information concerning friendly air operations. Aircraft sightings reported by pilots are also forwarded to the ABMOC.

B. EARLY WARNING DATA TRANSMISSION

Air defense early warning data is transmitted, within the Reliable STING system, in the form of track reports (see Table I). Each track report contains data obtained through the visual sighting or electronic detection of an aircraft. Reports include aircraft identification, location, size (number of aircraft), track designation, and aircraft type.

TABLE I

Example Track Report

ELEMENTS OF INFORMATION	EXAMPLE
IDENTIFICATION	HOSTILE
TRACK DESIGNATOR	347
LOCATION	JERSEY 5-5
RAID SIZE	ONE AIRCRAFT
AIRCRAFT TYPE	FAST MOVER

Location is the most difficult element of target information to pass within Reliable STING because the FAAR sections, the ADCS, and the ABMOC each operate on different reference systems. The Air Force, Hawk, and other HIMAD systems specify locations in terms of the World Geographic Reference System (GEOREF). The ABMOC and its users utilize the Universal Transverse Mercator System, with a map scale of 1:50,000. The FAAR sections operate on an absolute system, in which targets are located relative to the radar. Without a common reference system track information could not be passed accurately and quickly between elements. A common grid reference is provided through the use of a device called the SHORAD Grid.

The SHORAD Grid System is essentially a 400 element matrix (20-by-20) used for reporting target locations. Each element of the matrix is a 10-by-10 km square with a distinct name, "JERSEY" for example. The names are arranged in alphabetical order from left to right and top to bottom. The edges of each square are subdivided into 10-1 km increments. This allows the reporting of locations with an accuracy of 1 km. An aircraft located in the center of JERSEY would be announced as, "JERSEY 5-5" (see Figure 2).

The matrix covers a 200-by-200 km square, an area far larger than a standard division area of operations. The ABMOC orients the grid over the operating area and reports the coordinates of the center to all elements that are involved in the Reliable STING operation. Individual units use only that portion of the grid that covers their area of operations. It is significant to note that the entire division may cover less than 35 of these squares.

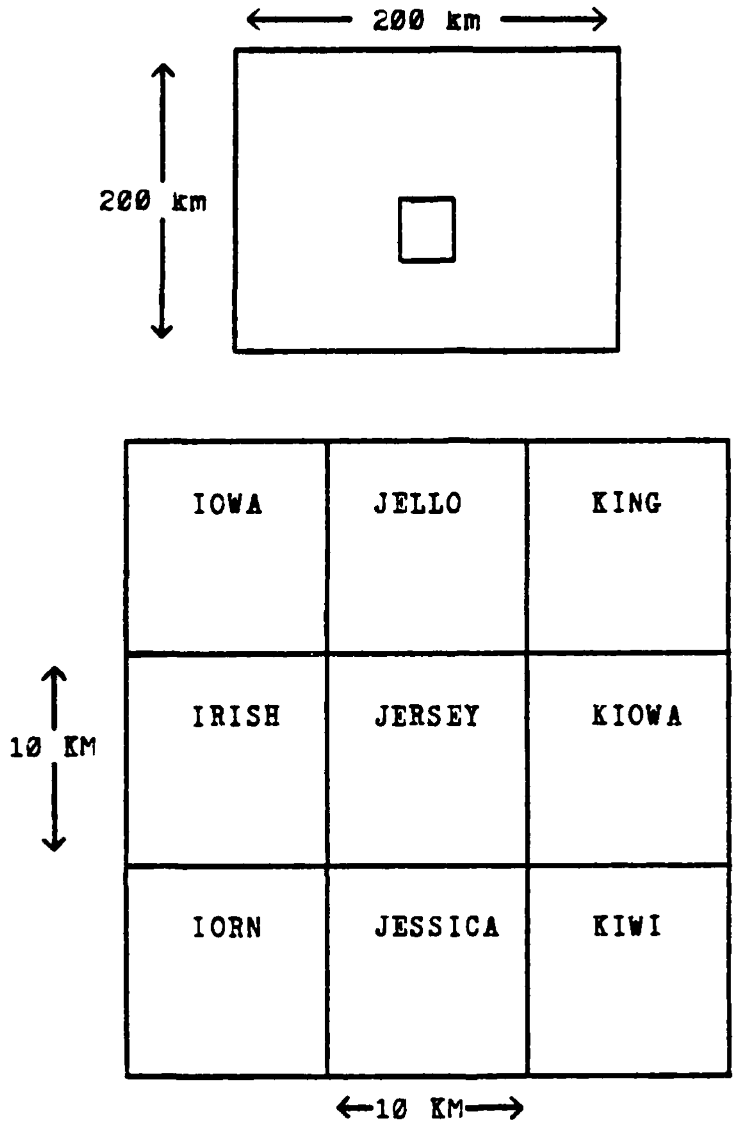
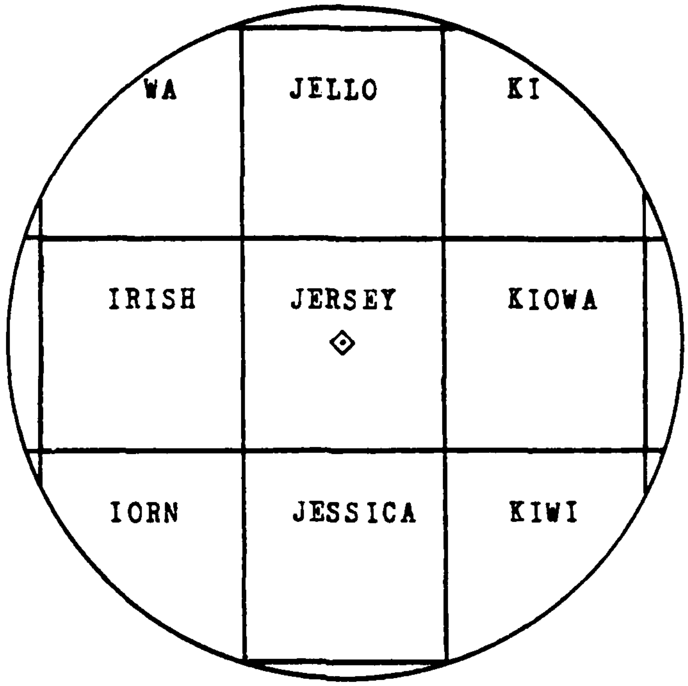


Figure 2. SHORAD Grid

FAAR operators overlay their display scope with an acetate sheet containing the grid designators for the portion of the matrix that is covered by their radar (Figure 3). The ADCS combines the SHORAD Grid System with a GEOREF overlay to provide a means of converting from one system to the other.



◇ - Aircraft located at JERSEY 5-5

Figure 3. FAAR Display With SHORAD Grid Overlay

The majority of the early warning track reports are transmitted to the ABMOC over five VHF/FM radio links (nets). One of these nets is utilized by the ADCS and the remaining four support the radiating FAAR. Each of the FAAR channels is used exclusively for the transmission of track reports to the ABMOC, operated as one-way channels. Operational control of the FAAR sections is conducted on a separate ABMOC operations net.

Long-range track reports are transmitted to the ABMOC on the air defense coordination net (ADCN). The ADCS also uses the ADCN to transmit command and control directives, exchange coordination information, and receive track reports from the ABMOC. The ABMOC notifies the ADCS of tracks that threaten Hawk elements (targets that may not have been detected by Hawk radar due to masking).

C. NON-EARLY WARNING INPUT

In addition to track reports, the Reliable STING system receives and processes other information originating from a number of sources. This information can be categorized as either coordination, emergency alert, or command and control information.

1. Coordination Information

Two elements perform extensive coordination with the ABMOC: the DAME and the FCC. The DAME is responsible for managing the use of the division's airspace. This responsibility involves interfacing between the division staff, the air defense commander (ADO) and his staff, the corps airspace management element, air force representatives, and the ABMOC. The DAME provides the ABMCC with information concerning maneuver operations, friendly/enemy situation, and airspace control measures.

The FCC monitors friendly air operations over the division. This is extremely important for friendly helicopter operations. Since their attempts to utilize masking terrain will prevent FAAR and Hawk from maintaining continuous surveillance. The FCC can assist in identifying these aircraft if they are not identified when they are detected by friendly units.

2. <u>Emergency Alert Information</u>

Nuclear, Biological, and Chemical (NBC) warnings, enemy airmobile alerts, and electronic warfare threats are examples of emergency alert information. The majority of these reports originate or are transmitted through the division tactical operations center. The DAME passes these reports to the ABMOC. Suspected enemy airmobile operations may be detected and monitored by the ABMOC.

3. <u>Command and Control Information</u>

Reliable STING receives air defense command and control information from two sources: the regional air defense commander and the division ADO. The regional air defense commander prescribes the rules of engagement (hostile criteria and weapons control status), states of alert, and air defense warnings. These directives are disseminated through command and control channels an Air Defense Coordination Section (ADCS - one officer, one NCO, and down to the Hawk battalion and/or the DAME. They are then transmitted to the ABMOC. Inputs from the division ADO are received from the DAME or the SHORAD battalion tactical operations center.

D. ABMOC

The ABMOC is the heart of Reliable STING, performing four functions which characterize the centralized nature of the system:

- The ABMOC receives track reports from both short and long-range sources identified above.
- It consolidates these reports to produce a "picture" of the division air battle.
- It attempts to correlate the track reports with known air operations to increase the "value" of the report.
- While these actions are taking place, the ABMOC is continuously transmitting air defense early warning information to the entire division.

The functions identified above are all performed manually. The ABMOC operation centers around three plexiglass plotting boards: a main plotting board, a long-range plotting board, and a friendly aviation board (see Figure 4). Each board contains a diagram of the current division boundaries and has the SHORAD Grid etched into its surface (1:100,000 scale on the long-range board and 1:50,000 on the friendly aviation and main plotting boards).

Long-range tracks that pose a threat to the division are initially plotted on the long-range board. The main plotting board is only 80-by-70 km and many of these tracks are outside its coverage. This procedure also reduces the number of tracks that must be maintained on the main plotting board. As aircraft approach the division, or if the initial track report from the ADCS is over the division, the track is transferred to the main plotting board. The main plotting board contains the tracks of all unknown and enemy aircraft detected over or near the division's area of responsibility. The friendly aviation board contains all the information the ABMOC has concerning friendly air operations (air corridors, ongoing missions, preplanned mission information, etc.). Tracks are plotted and updated by five plotters.

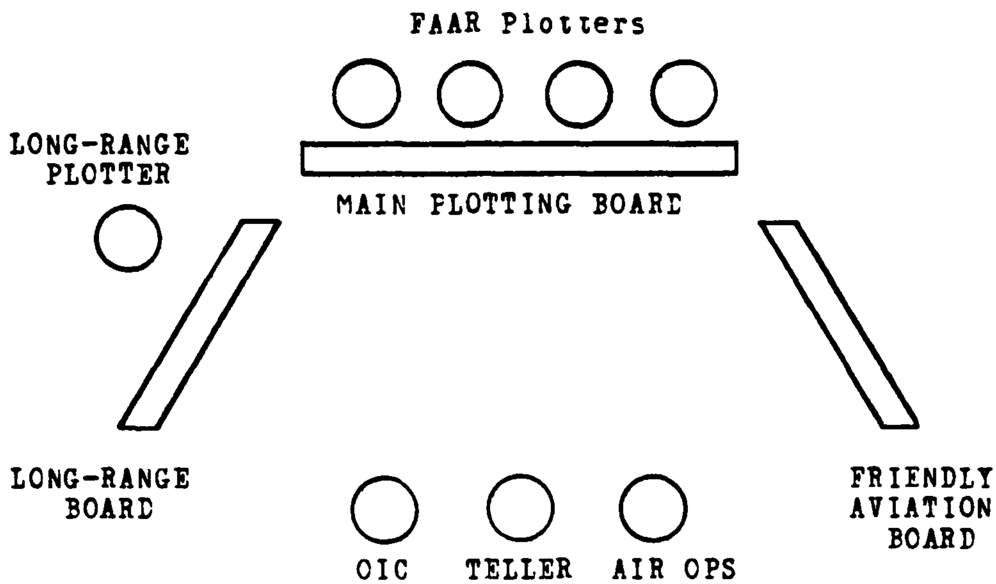


Figure 4. ABMOC Operations

One plotter monitors the ADCN and maintains the long-range plotting board. The other plotters work the main plotting board, monitoring one FAAR each. The plotters mark the location identified in the track report on the back of the board. If the report is an update of a previously reported track, the point is connected by a line to the last reported location. The update reports provide the actual "track" which can be analyzed by ABMOC personnel to predict an aircraft's heading.

Positioned where they can observe all three boards are the Officer-in-Charge (OIC)/Operations Officer and the NCC-in-Charge (NCOIC)/Teller. The OIC and NCOIC correlate the information on the three boards. Unknown tracks are compared to known air operations, in an attempt to determine possible identification. The OIC is responsible for the entire Reliable STING operation, to include: determining FAAR coverage and positioning, controlling FAAR search operations and managing the flow of air defense early warning information to the division. The NCOIC acting as the Teller, transmits the track reports to the division's users.

E. DIVISION AIR DEFENSE EARLY WARNING NET

Reliable STING transmits information to its users over the Division Air Defense Early Warning (DADEW) Net. To reach its users, the ABMOC simultaneously transmits both VHF/FM and HF/AM signals. The FM signal is intended for those elements deployed near the ABMOC, while the AM signal is received by three retransmission sections. Each of these sections maintains an HF/AM receiver which is patched to a VHF/FM transmitter. The incoming signal is received on the HF/AM receiver and retransmitted to users over the UHF/FM transmitter. The retransmission stations are positioned where they can support the the majority of the divisional users (with priority to SHORAD and maneuver units.

The track report (Table I) is also used as the format for DADEW information. DADEW track reports include the same types of information as the sensor reports. One additional element of information is included in track updates: predicted heading (eight cardinal directions are used, north, northeast, east, etc.).

III. USER INFORMATION REQUIREMENTS

The first step in analyzing the performance of Reliable STING is to determine the information requirements of the system's users. Information requirements will be ordered from the most basic need to those elements of air defense information that support optimum user performance. This entails identification of the users, their missions, the threat they must counter, and the air defense information they require to accomplish their missions.

TABLE II

System Users

CATEGORY	DECISION MAKER	TYPE OF DECISION
1	ADO	LONG-RANGE PLANNING
2	DAME, SHORAD CMD	MANAGEMENT/COORDINATION
3	FIRE UNITS	OPERATIONAL

A. THE USERS

Any individual that makes use of information provided by Reliable STING is considered a system user. A list of potential users could include the entire division. Theoretically, anyone with a VHF/FM receiver tuned to the proper frequency may monitor the division air defense early warning net. These information consumers can be placed into one of three categories based upon the types of decisions they make (see Table II). [Ref. 5] The decisions that the air defense elements in each of these categories make, result from their position within the division air defense organization.

- CATEGORY I - Long-Range Planning Decisions.

  The first category is comprised of the division air defense officer (ADO) and his staff. The ADO is tasked with providing sufficient air defense support to allow the division commander to achieve his goals. He and his staff must analyze the enemy/friendly situation, the objectives of each side, and the status of friendly air defense assets. All this must be accomplished before the air battle begins.

- CATEGORY II - Management and Coordination Decisions.

  The SHORAD leadership (battery and platoon) and the division airspace management element (DAME) are concerned with the implementation of the plans and procedures established by the ADO, they are included in the second category. The DAME attempts to effectively manage the division's airspace by making decisions concerning the coordination of air defense and air support assets. The SHORAD command elements are involved in the management of their primary resource, air defense fire power.

- CATEGORY III - Operational Decisions.

  The third category is made up of the SHORAD fire units. Their major concerns are not planning, management, or coordination. The fire units make decisions concerning immediate threats to themselves and the units/assets they are defending.

This examination will focus on the information needs of the operational users, the SHORAD fire units. These are the elements that Reliable STING was designed to support. Their support is the primary goal of the present system as well.

B. THE SHORAD MISSION

An understanding of the SHORAD fire units' role in the defense of the division is a precursor to analysis of their information needs. This role is identified through examination of the missions performed by SHORAD fire units in light of the air threat to the division. Through this examination, the inherent decisions and the information requirements can be identified.

1. Air Threat

Before exploring specific elements of the Soviet air threat, it is useful to examine the general air threat directed against ground forces. Cohen [Ref. 6] identifies five elements that compose the air threat:

1. Air threats to maneuver forces deployed for combat.

2. Air attacks to the division's central and rear regions against reserves and critical assets.

3. Airborne assaults into the central division area, surveillance and jamming from air vehicles, and other enemy uses of the airspace over the division which are not direct attacks.

4. Air threats against targets in the corps and theater areas by enemy aircraft overflying the division.

5. Air defense suppression by enemy air.

Of these five threats, the first two cause the greatest concern at division level. Soviet aircraft directed against maneuver forces, reserves, and critical assets jeopardize the accomplishment of the commander's objectives.

Maneuver units deployed along the FEBA face two air threats. The first of these consists of high performance aircraft providing close air support for enemy ground forces. The Soviets maintain a large arsenal of MiG-21's, MiG-23's, Su-7B's, and Mig-27's capable of performing a ground attack role. These aircraft will ingress at low altitude to mask their movements from HIMAD systems, at speeds between 300 and 900 knots. By taking advantage of terrain and speed, their observation by ground forces can also be limited. In the vicinity of the target, aircraft speeds will be reduced to approximately 400 knots, as dictated by the altitude and method of attack.

Attack helicopters represent the second and most dangerous threat to maneuver operations. The use of attack helicopters, a tactic developed by the U.S. to counter the Soviet ground threat, has become a key element of Soviet doctrine. Soviet emphasis in this area has produced the MI-24 HIND, the most lethal helicopter in the world. Heavily armed with anti-tank guided missiles, rockets, and gun armament, the HIND flys in support of ground forces. Attack helicopters will operate at much lower speeds than fixed-wing aircraft, and their ability to take advantage of masking terrain is greatly increased.

The primary air threat to critical assets in the central and rear areas of the division and to division reserves, consists of high performance ground attack aircraft. Where low-level flight is important to the accomplishment of the opposing force's close air support mission, it is critical to this mission due the depth of targets behind the FEBA.

There are common characteristics in each of the threats identified above that impact upon SHORAD fire units' ability to perform a successful engagement. High performance aircraft are going to be flying extremely fast and very low. These factors combine to shorten the detection range and reaction time available to perform identification and engagement decisions. Even though attack helicopters will fly at much slower speeds than fixed-wing aircraft, their ability to take greater advantage of masking terrain provides the same results.

2. SHORAD Missions

Divisional air defense assets, as shown in Figure 5. include Chaparral, Vulcan, and Redeye fire units. These elements are deployed to defend maneuver forces, reserve forces and other critical assets, according to the division commander's priorities. Chaparral and Vulcan units comprise the division's air defense battalion. Redeye sections are currently organic to the artillery and maneuver battalions.

The division ADO (the SHORAD battalion commander) has historically had more requests for air defense support than he has had assets capable of supporting. As a result, the requirements for these assets must be prioritized. Based on that prioritization, air defense units are organized for combat. This involves task organizing and mission assignment.

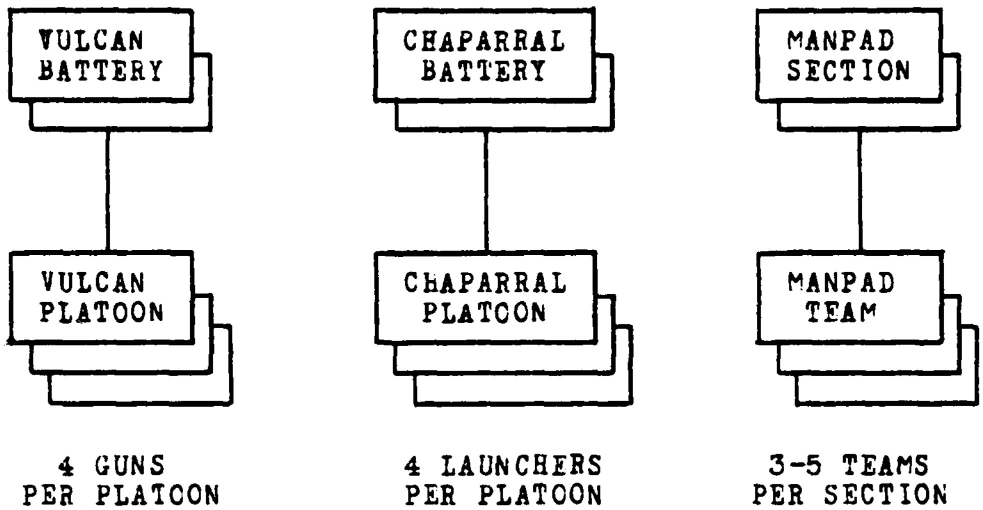


Figure 5. Division Air Defense Assets: Infantry, Mechanized Infantry, and Armor Divisions

Four tactical missions are generally used: Direct Support (DS), Reinforcing (R), General Support-Reinforcing (GSR), and General Support (GS). It should be noted that each of these missions is a support mission, ranging from decentralized control (direct support) to centralized control (general support).

The tactical mission specifies the degree of control the division commander (as advised by the ADO) wishes to exercise over the SHORAD elements. The tactical mission identifies who is responsible for positioning the units, what liaison links must be established, and which requirements for air defense support will be accepted by the unit.

Vulcan batteries generally provide direct support for maneuver units or reinforce Chaparral elements to provide a mix of weapons and additional fire power. Typical missions are defense of critical maneuver battalions, maneuver or logistics convoys, and forward deployed support assets. Chaparral batteries are often tasked to provide general support of the division or general support-reinforcing (under GSR another unit would be reinforced when the battery was not required to support the division as a whole). Their missions would include defense of rear area assets like the division support command, brigade trains, and the division command post.

The Redeye section is deployed according to the priorities established by the supported battalion commander. Redeye teams normally defend maneuver companies, battalion level assets (command post or logistic trains), or some combination of the these.

C. SHORAD INFORMATION REQUIREMENTS

To successfully accomplish the missions identified above fire units require information from the SHORAD command and control system. The required elements of information must first be identified. Once this has been accomplished, essential elements of information can be determined and the users' requirements can be prioritized.

1. Identification of Requirements

Critical to the identification of information requirements is the realization that the SHORAD fire unit has two sets of air defense information needs. The first set is generated by the nature of the fire unit's task and includes elements of target information. The second set of information needs is imposed on the fire unit by SHORAD command and control doctrine. These procedures establish the user's need for information that provides some degree of centralized control. Both of these requirements are elaborated below.

Everything that the fire unit does is related to engaging aircraft. Therefore, an analysis of the engagement process will serve as a basis for the identification of the user's information needs. Lawson's model of the command and control process provides a framework for examining the engagement process (see Figure 6). [Ref. 7] Within the basic model there are four functions that must be performed: SENSE, COMPARE, DECIDE, and ACT. The major functions included in the engagement process can be identified in this manner:

- SENSE

  The fire unit must search the environment for aircraft, a sensing function.

- COMPARE

  Once an aircraft has been detected, the fire unit attempts to determine its identity through comparison.

o DECIDE

After the aircraft has been identified, the unit must decide whether or not to engage.

o ACT

The fire unit will take appropriate action and attach the aircraft if the decision to engage is made.

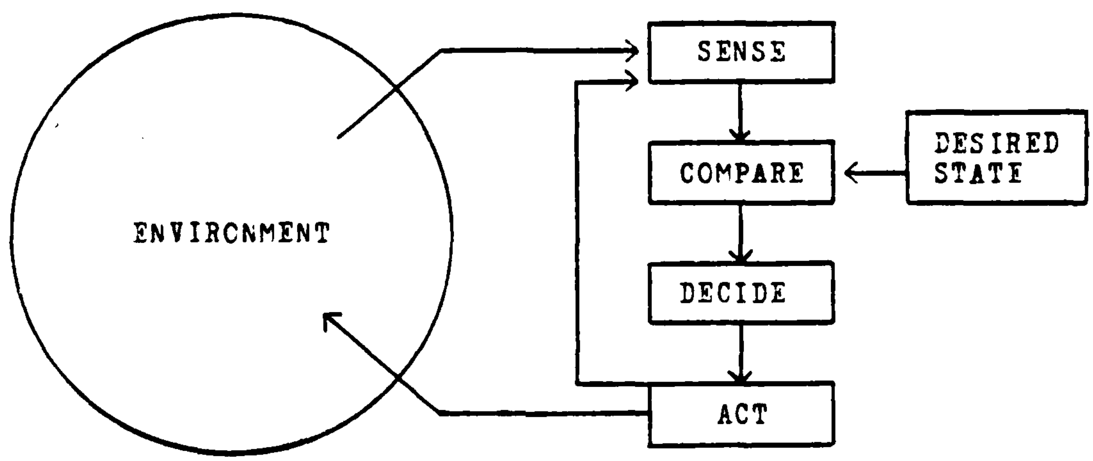


Figure 6. Command and Control Process

The functions mentioned above must be performed correctly to produce a successful engagement. The performance of these functions requires the following information:

a. Mission, Sector of Fire, and Primary Target Line

Battery commanders and platoon/section leaders are able to tie their fire units together into a structured defense by controlling the distribution of fires. Fire distribution includes the assignment of primary target lines (PTL-the direction in which the fire unit is oriented) and sectors of fire (left and right limits) for each unit. This guidance allows the fire unit to focus on a portion of the environment. This procedure can be used to ensure that there are no gaps in coverage and also reduces the probability of unnecessary mulitple engagements of the same aircraft.

b. Air Defense Warning and States of Alert

Advanced warning is required to ensure that fire unit crews have sufficient time to prepare for action. Air defense warnings are used by the regional air defense commander to identify the probability of air attack. Three warnings (RED, YELLOW, and WHITE) are used to represent attack imminent/under way, attack probable, or attack not probable. These warnings are not geographically specific, and the entire division will receive the same warning.

States of alert are closely related to air defense warnings. They specify the amount of time available for preparation for engagement (time to assemble off-duty personnel, prepare ammunition,etc.). States of alert are specified by standard operating procedures (SOP's). Two examples are: "BATTLE STATIONS", which instructs units to be prepared to engage aircraft, and "STANDBY", which directs units to be ready to execute "BATTLE STATIONS" in a matter of minutes. The unit SOP would relate these states to the air defense warnings. Under air defense warning "RED" all units may be directed to assume "BATTLE STATIONS".

c. Rules of Engagement

Some control over the SHORAD engagement process is exercised through the use of air defense rules of engagement. Individuals attempting to engage aircraft are aided and constrained by the two components of the rules of engagement: hostile criteria and weapons control status.

Hostile criteria are used to identify enemy aircraft. The most common criteria are: aircraft with enemy markings, the type of aircraft operated by the enemy, and aircraft observed attacking friendly units. Additional criteria may be established, for example: "All helicopters operating over the division between 0600 and 1000 hours are to be considered hostile." This would be a case where no friendly helicopters would be operating over the division during this time.

The second element of the rules of engagement is weapons control status. Three statuses are utilized: weapons free, weapons tight, and weapons hold. Weapons free grants the squad/team leader the authority to engage any aircraft not positively identified as friendly. Weapons tight directs that only those aircraft positively identified as hostile may be engaged. Under weapons hold units may only fire at aircraft which are attacking them or the units they support.

d. Target Information (Track Reports)

Information concerning specific aircraft flights can range from alerting information to cueing data. Alerting is the form of early warning in which units are advised that aircraft are operating in their area of concern. Cueing information is more specific; aircraft location, identification, heading, and others may be provided. Depending upon its accuracy, this information can allow the fire unit to prepare for a specific engagement.

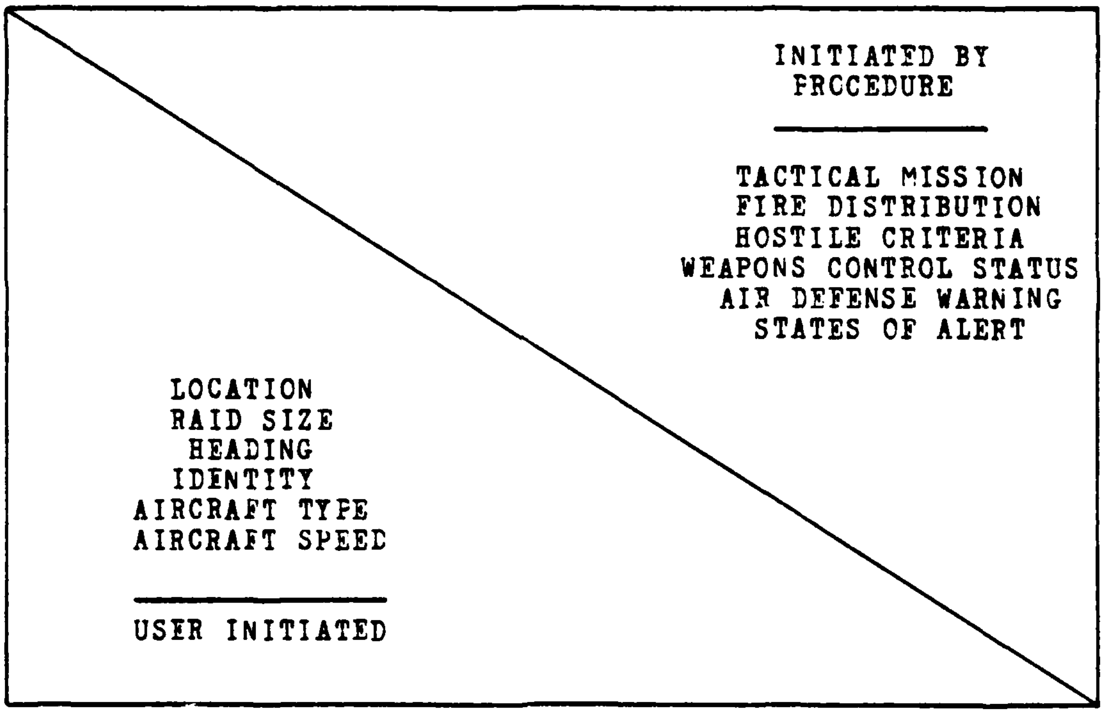


Figure 7. User Information Requirements

A list of the user information requirements is contained in Figure 7. User initiated needs are distinguished from those information requirements dictated by operating procedures. The different elements of specific flight information have been listed individually, although location is necessary to give meaning to the others.

2. Essential Elements of Information

There are essential elements of information that must be provided in order to achieve minimum effective performance. This level of performance is supported by providing a mission and the information that is required to allow the engagement process to take place. The user must be able to SENSE, COMPARE, DECIDE, and ACT. If any of these cannot be performed, the engagement cannot take place.

To effectively perform the SENSING function, the fire unit must have a PTL and air defense warning/status of alert information. Once the fire unit is assigned a PTL, the crew can position themselves to search in the desired direction. The gunner will search +/-45 deg of the PTL, while other crew members cover 180/360 deg sectors. The warning/alert information increases the probability of detection by improving crew readiness.

During the COMPARISON function, the decision of whether or not the aircraft is hostile must be made. The minimum amount of information required is the hostile criteria. Theoretically, this is the only step that is not required. It is possible to engage an aircraft without deciding if it is friendly or hostile. This would be far short of minimum effective performance.

The DECISION function cannot be performed correctly without weapons control status and sector of fire. The control status, combined with aircraft identification and unit sector of fire, allows the engagement decision to be made. Like detection, this function is required if an engagement is to take place.

TABLE III

Minimum Information Requirements

	TACTICAL MISSION
	HOSTILE CRITERIA
	WEAPONS CONTROL STATUS
	FIRE DISTRIBUTION
MINIMUM	AIR DEFENSE WARNING
REQUIREMENTS	STATUS OF ALERT
	LOCATION
	IDENTIFICATION
	HEADING
	AIRCRAFT TYPE
	RAID SIZE
	AIRCRAFT SPEED

The ACTION function requires information concerning the air defense warning/states of alert. The warning/alert information brings the crew to an increased state of readiness. Engagement preparations can be made prior to detection, increasing the amount of time available for acquiring, tracking, etc.

At this point it can be seen that the first five categories of information are necessary to support the engagement process. Each of these elements is required for minimum effective performance. Given this information the fire unit can deploy and operate without specific flight information and perform its mission. Any prioritization must occur between the minimums and the elements of target information (see Table III).

3. Requirement Ranking

It is important to take the elements of information identified above and rank them from the most important to the least important. It may not be possible to provide all of the information required by the fire unit. There may also be trade-offs between the accuracy of different elements. In these cases, emphasis should be placed upon the higher priority items. The following is a suggested ordering of information requirements:

1. Minimum Requirements. Tactical mission, hostile criteria, weapons control status, fire distribution, air defense warnings, and states of alert.

2. Aircraft Location. Aircraft location can be specified as part of early warning/alerting information or as specific cueing information. Location is the most critical piece of target information.

3. Identification. Even though the identification supplied by an outside source (FAAR for example) may be correct, the squad/team leader must make a positive visual identification. A tentative identification can assist in this process.

4. Heading. Heading can be combined with location to produce a reckoned update to target location.

5. Aircraft Type. The identification of aircraft type aids in target detection and identification by telling the fire unit what to look for. The type also provides some limits on the operating speed of the aircraft.

6. Raid Size. The number of aircraft is another characteristic that aids in detection. Fire units are also alerted to the possibility of mulitple engagements.

7. Aircraft Speed. Knowledge of the aircraft speed, when combined with heading and location, can aid in detection. Knowing the aircraft speed is also important when considering how to engage the aircraft.

When aircraft speed, heading, or aircraft type are used as elements of hostile criteria (example: "All high-performance aircraft operating over the division between 062000Z-0708000Z are to be considered hostile.") they would be as important as identification.

As there is a minimum effective performance, there must also be an optimum performance. All aircraft that entered the fire unit's sphere of influence would be detected. This detection would occur at the maximum range. All detected aircraft would be identified at the maximum identification range. Following the engagement decision, the gunner would destroy each hostile aircraft engaged.

Each of the elements of target information has an accuracy associated with it. Identification may be "probable" or "tentative". Location accuracy may establish a large or small search sector. Optimum performance would be supported by perfect information in each of these categories. Table IV demonstrates the relationship between these levels of information support.

TABLE IV

Information Requirements Verses
Performance Level

ELEMENT	MINIMUM EFFECTIVE PERFORMANCE	OPTIMUM PERFORMANCE
MISSION	X	X
HOST. CRIT.	X	X
WEAP. STATUS	X	X
FIRE DIST.	X	X
AD WARNING	X	X
ST. OF ALERT.	X	X
LOCATION (SECTOR SIZE)	(+/-45)*	X(+/-1)
IDENTIFICATION		X(ACTUAL)
HEADING		X(ACTUAL)
AIRCRAFT TYPE		X(ACTUAL)
RAID SIZE		X(ACTUAL)
AIRCRAFT SPEED		X(ACTUAL)

X - Information provided

* - A result of PTL assignment
(sector size in degrees)

IV. INFORMATION RESOURCES

In Chapter III the users' requirements for air defense information were identified. Any system that attempts to satisfy these requirements must gather substantial amounts of information. Two basic resources are available to provide this information: air defense command and control/early warning information and track reports. Prior to addressing the effectiveness of any SHORAD command and control system, it is necessary to ascertain the adequacy of information available from these resources.

A. AIR DEFENSE COMMAND AND CONTROL

Air defense command and control information includes all information directed at increasing unit readiness (reducing reaction times), establishing support requirements, and maintaining control of subordinate units. This information is processed through the air defense chain of command and through control and coordination links. Sources of command and control information can be found both within and outside the division, they are:

- The regional air defense commander
- The division air defense officer
- SHORAD leaders
- Maneuver commanders

1. External to Division

The regional air defense commander, normally the senior Air Force commander, is the primary external source of air defense command and control information. Although he does not possess command or operational control over the divisional air defense assets, he does exercise control over the use of all air defense weapons within the region. He does this through the use of rules of engagement and air defense warnings. Rules of engagement and air defense warnings are transmitted to the supporting Hawk battalion by TSQ-73 data link from the air defense group/brigade supporting the corps. From the Hawk battalion there are two routes into the division, resulting from an exchange of liaison officers between the division and the Hawk battalion. The SHORAD battalion dispatches an air defense coordination section to the Hawk battalion command post and the Hawk battalion sends a liaison section to the division main tactical operations center. The SHORAD liaison section collects and transmits information concerning the rules of engagement and air defense warnings to the SHORAD tactical operations center (or to the ABMOC in the 9th ID), where it can be disseminated to subordinate units. Prior to the implementation of MSCS, this information was disseminated over SHORAD command nets. Both MSCS and Reliable STING broadcast these elements of air defense information over early warning nets. The Hawk battalion also transmits this information to their liaison section, who reports it to the DAME. Personnel in the DAME pass the information to the division operations element, who can disseminate it down through the maneuver chain of command (tactical command post (CP), brigade CP's, battalion CP's, etc.).

2. Internal to Division

Within the division, air defense command and control information is provided by three sources:

o The division air defense officer.

o SHORAD battery commanders and platoon leaders.

o The division, brigade, and battalion commanders.

The information they provide is identified below.

Tactical missions are assigned at two different levels. The division commander, acting upon the advice of the ADO, assigns battery, and in some cases platoon, missions in the division operations order. Batteries assigned the mission of direct support come under the control of the supporting unit. Missions for Redeye teams are determined by the battalion commander and the Redeye section leader. Coordination with supported maneuver units at these levels is an important part of mission definition.

SHORAD battery commanders and platoon leaders provide information concerning PTL's and sectors of fire. Depending upon the size and value of the asset, a battery or platoon-sized unit will generally provide the air defense.

The commander of that unit will establish these measures for subordinate units in the construction of his defense.

States of alert are also generated within the division. Standard operating procedures identify the states which correspond to the air defense alert warnings. Battery commanders have the authority to reduce the states of alert of selected elements in order to maintain increased long-term readiness.

Maneuver commanders are given the authority to implement more restrictive weapons control statuses in their area of operations. By changing the status, the commander exercises a greater degree of control over the air defense fire units within his sphere of influence. This procedure would be used in conjunction with critical friendly air operations.

3. Level of Support

These elements of information meet the users' minimum essential requirements (see Table V). The same command and control procedures that established the requirements establish the reporting procedures. There is no accuracy associated with these categories of information. The requirement is either satisfied or it is not satisfied. It should also be noted that because externally generated command and control information pertains to the entire air defense region, is well suited for division-wide broadcast.

TABLE V

Sources of Air Defense Command and and Control Information

ELEMENT	INFORMATION PROVIDED EXTERNAL TO DIVISION	INTERNAL TO DIVISION
MISSION		X
HOST. CRIT.	X	
WEAP. STATUS*	X	X
FIRE DIST.		X
AD WARNING	X	
ST. OF ALERT.		X

X - Information provided

* - Provided by both sources

B. TRACK REPORTS

The second major source of information is aircraft track reports. Track report information is required to fulfill early warning/alerting and cueing requirements. These reports contain information relating to specific aircraft flights and may be processed manually or electronically. Track reports are originated by Air Force and Hawk radar, organic FAAR sections, and by friendly aviation.

1. FAAR

The FAAR system is SHORAD's only organic means of electronic aircraft detection. When used with the target alert data display set (TADDS), this system is designed to provided the SHORAD fire units with alerting information for targets within 20 km of the radar.

The FAAR system consists of four major components:

- o A radar set.
- o An interrogation friend or foe (IFF) system.
- c A communications system.
- o Target alert data display sets.

The radar detects aircraft and displays them to the FAAR operator on a cathode ray tube (CRT) display. Using the IFF system, the operator determines a tentative aircraft identification. Under standard procedures, one of the FAAR section's radios is used to transmit this information to the TADDS devices located with Chaparral and Vulcan squads and Redeye teams.

The TADDS device is a VHF/FM radio receiver with a built-in 7-by-7 matrix display. Each of the 49 windows, which is capable of displaying friend and/or unknown indicators, represents a 5 km square. A radio-frequency-data-link (RFDL) from the FAAR is used to transmit location and tentative identification to the TADDS device. Under the Reliable Sting concept this information is transmitted by voice to the ABMOC.

With the FAAR/TADDS system, the FAAR operator reports locations to the SHORAD elements to the nearest 5 km. The Reliable STING system does not make use of the TADDS box, but through a procedural change, allows the FAAR operator to provide more accurate reports. This change includes placing a SHORAD Grid over the CRT display, as discussed in Chapter III. With this, the operator is able to estimate target locations to the nearest 1km. This information, along with tentative identification, type of aircraft (fast verses slow), and relative number of aircraft in the raid, is transmitted to the ABMOC, rather than to the SHORAD fire units.

Experiments conducted during the 1960's and early 1970's demonstrated that single engine, high-performance aircraft could be visually detected beyond 10 km. [Ref. 8] Because these results were achieved under excellent visibility conditions, detection ranges of 3-8 km suggested by FM 44-23 [Ref. 9], are assumed to be more accurate in the European environment. In the remainder of this document, the maximum figure of 8 km will be used for comparisons of location accuracy. Allowing the fire unit crew to detect at their maximum detection range should be a major goal of any early warning system.

Figure 8 illustrates the size of the search sector corresponding to a 1 km accuracy, at ranges out to 10 km. A FAAR report with 1 km accuracy establishes a 7.6 deg search sector at 8 km. This represents the report accuracy as the FAAR operator prepares to transmit it. If the target is a high-performance aircraft flying at 400 knots, it travels at over 200 m/sec. Assuming that the operators report requires five seconds to transmit (transmitter keying time included), the aircraft will have flown at least 1 km by the end of the

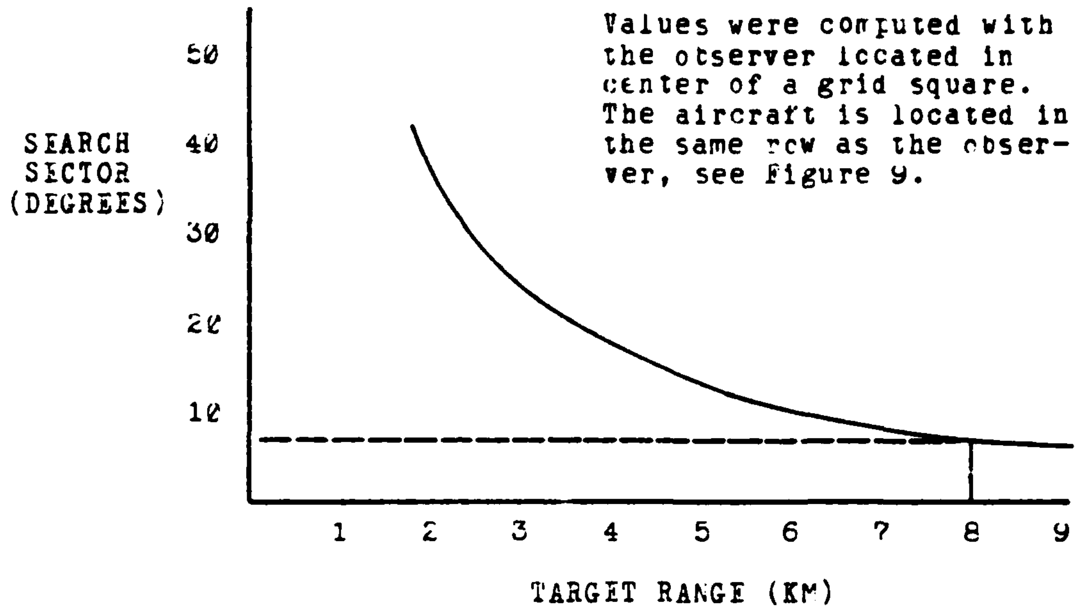
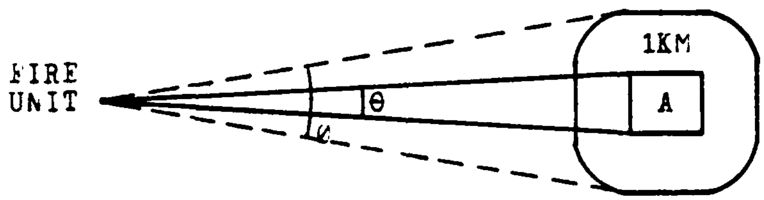


Figure 8. Search Sector Size for 1 km Report



θ = 7.6 Degrees
Ø = 22.6 Degrees (5 second report delay, aircraft speed - 400 knots)
A - Aircraft located to the nearest kilometer 8 km from the fire unit.

Figure 9. Sector Size Verses Time Delay

report transmission. The effect of this delay is to effectively triple the size of the necessary search sector (see

Figure 9). The aircraft was somewhere within the 1 km square prior to transmission, however, the delay would allow a high performance aircraft to reach the limits of the outer figure.

The level of information support available from the FAAR sections is portrayed in Table VI. The search sector at 8 km is +/-11.3 deg. Potential targets remain classified as friendly or unknown until a visual identification is made or elements of hostile criteria identify the aircraft as hostile. Fast aircraft will be distinguished from slow aircraft, allowing the FAAR operator to provide some information concerning aircraft type and speed. Also, depending upon the spacing between aircraft, a relative number of aircraft can be determined. It is possible for the FAAR operator to provide heading information. However, additional processing requirements (plotting targets and observing their flight path) would have an adverse impact upon the accuracy of the location information.

Another consideration associated with manual transmission of track reports is the track handling rate. Using the same five second report duration assumed above, under perfect conditions an operator can only make 12 reports in one minute. With only one aircraft on the display, the accuracy of the reports will be the same as previously discussed. As more aircraft are processed, the average time between reports on a given aircraft is

TABLE VI

Target Information Available to Support Reliable STING

ELEMENT	
LOCATION (SECTOR SIZE)	X(+/-11.3)
IDENTIFICATION	X(FRND./UNK.)
HEADING	
AIRCRAFT TYPE	X(FAST/SLOW)
RAID SIZE	X(RELATIVE)
AIRCRAFT SPEED	X(FAST/SLOW)

X - Information provided

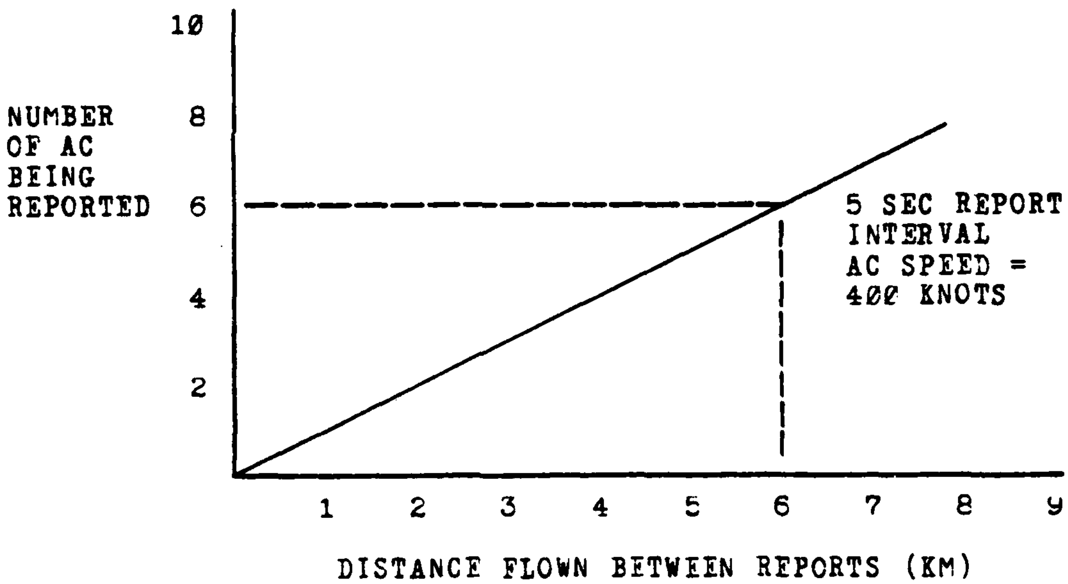


Figure 10. Distance Flown Between Reports

proportional to the number of aircraft being reported. If the FAAR operator would attempted to track six aircraft, providing updates on each of their locations, they would each be reported once every 30 seconds. Figure 10 illustrates the proportionality. For an aircraft travelling at a speed of 400 knots, when the report interval is five seconds, the average distance (in kilometers) traveled between reports is approximately equal to the number of aircraft in the system. The update interval is a factor of the report interval times the number of aircraft being reported. The update interval times the speed of the aircraft produces the distance travelled between reports (see the example below).

$$5 \text{ sec} \times 6 = 30 \text{ sec}$$
$$30 \text{ sec} \times 200 \text{ m/sec} = 6 \text{ km}$$

The FAAR operator is not required to cycle through all of his tracks, making a report on each one. He may concentrate on a particular aircraft that he feels poses the greatest threat. By doing this, the time, and hence the distance traveled between reports for that aircraft will decrease.

2. Direct Support Hawk and Air Force

Long-range early warning information is provided by the Hawk battalion or the Air Force control center/point (CRC,CRP,FACP). The air defense coordination section that deploys to one of those locations is tasked to provide command and control information as previously discussed. The section also provides early warning track reports of aircraft approaching the division area.

At the Battery Control Central (BCC) or the Battalion Operations Center (BOC), the liaison officer (LNO) positions himself where he can observe the CRT display of acquisition radar returns. He identifies long-range aircraft tracks that threaten to enter the division airspace. The GEOREF location of these aircraft is determined and transmitted (along with tentative identification and other elements of information) to the remainder of the section located nearby. The section plots the track in GEOREF on an acetate plotting board. Since this plotting board has GEOREF coordinates on one side and the SHORAD grid on the other side, a location can then be read from the SHORAD grid side and transmitted, along with the other pertinent information received from the LNO, to the ABMCC.

When the observer monitors the radar display in the BCC or the BOC, he is able to see the targets detected by the battery's pulse acquisition radar (PAR) and continuous wave acquisition radar (CWAR). These radar systems have operational ranges in excess of 100 km and 60 km respectively. To present these radar returns, the CRT display has a scale at least five times greater than the FAAR display. The entire SHORAD Grid, which represents and area 200-by-200 km, is not large enough to cover the Hawk display. Unfortunately for the sake of accuracy, the displayed radar returns are approximately the same size as those on a FAAR display. It is difficult to accurately locate an aircraft in this manner, when the projection of its radar return is larger than the unit of measure.

Even if very accurate readings could be made, additional error is incurred by determining the locations in GEOREF (to the nearest minute) and then transforming them to SHORAD Grid coordinates (to the nearest 1 km). The relationship between minutes and kilometers varies as a factor of latitude. In Central Europe a minute is approximately 1 km in longitude and 2 km in latitude. The coordinate transformation performed by the coordination section cannot improve this accuracy.

The transformation/reporting process performed by the section takes at least twice as long to accomplish as the FAAR operator's reporting. The delays imposed by voice reporting are basically the same in both locations because both sources are transmitting identical elements of information.

The BOC also receives track information originated by Air Force sensors. These reports are received via the TSQ-73 link to the parent air defense brigade or group. One source of information for these reports is the Air Forces' Airborne Warning and Control System (AWACS), which is linked to the CRC supporting the corps.

At operational altitude the aircraft has a horizon of approximately 250 miles. This range combined with the systems ability to identify aircraft from ground, allows

AWACS to provide exceptional long-range early warning against low-flying aircraft which may be masked from FACP or Hawk radar. Because the system must exclude ground it is not effective for detecting slow flying helicopters.

The 9th ID has operated directly with AWACS during joint exercises. An HF/AM voice link was established between the AWACS and the ABMOC for passing track reports. However, under standard operating procedures, the AWACS aircraft transmits high-speed digital information to the CRC. One of these aircraft is capable of supporting the entire air defense region. Given the range of its sensors (capable of covering many divisions) and the importance of its intercepter control mission, it is unlikely that AWACS will communicate directly with divisional air defense elements.

With the exception of heading and location/sector size information, Table VI also represents the level of information support available from the long-range sources. Unlike the FAAR sections, the coordination section is capable determining an approximate heading without increasing their processing time. This is because the coordination section must plot the track reports to transform the coordinates, whereas the FAAR operator does not. As a result of the processing delays and CRT display inaccuracies identified above, the sector size required to locate the target would be much larger than +/-11.3 deg sector which results from the FAAR reports.

3. Division Aviation

One of the sources of information identified for Reliable STING is the division's aviation assets. These aircraft can be divided into two groups: those aircraft operating along the FEBA, and those operating over the central and rear regions of the division. The latter group includes utility and cargo helicopters. These aircraft could observe enemy airmobile/airborne operations and ground attack aircraft directed against assets in these regions. Along the FEBA, observation and attack helicopters are in position to observe air strikes directed at maneuver elements, to include enemy attack helicopter operations.

Enemy aircraft sightings are transmitted to the Flight Control Center (FCC). The FCC transmits these reports to their cell located with the ABMOC. Because these reports are visual sightings of moving targets made by observers who are also moving, it is impossible to determine the accuracy of any locations received from this source.

4. Level of Support

The track report information available to the Reliable STING system is capable of satisfying the remainder of the users' air defense information needs (see Table VII). The accuracy of the locations provided by FAAR falls between those required for minimum and optimum levels of performance. The information required to support each of these elements, except for heading, can be provided by FAAR.

TABLE VII

Information Available to Support STING
Reliable STING

ELEMENT	REQUIRED FOR MINIMUM EFFECTIVE PERFORMANCE	INFORMATION AVAILABLE	REQUIRED FOR OPTIMUM PERFORMANCE
MISSION	X	X	X
HOST. CRIT.	X	X	X
WEAP. STATUS	X	X	X
FIRE DIST.	X	X	X
AD WARNING	X	X	X
ST. OF ALERT.	X	X	X
LOCATION	(+/-45)*	X(+/-11.3)	X(+/-1)
IDENTIFICATION		X(FRND./UNK.)	X(ACTUAL)
HEADING		X(ADCS)	X(ACTUAL)
AIRCRAFT TYPE		X(FAST/SLOW)	X(ACTUAL)
RAID SIZE		X(RELATIVE)	X(ACTUAL)
AIRCRAFT SPEED		X(FAST/SLOW)	X(ACTUAL)

X - Information provided

* - A result of PTL assignment
(Sector size in degrees)

Other sources also provide important input. The long-range track reports bridge the gap between very general air defense warnings and alerting/cueing information. This early warning benefits the users in two ways. It increases their level of readiness and provides the ABMOC OIC the information necessary to allow him to employ the best combination of operating FAAR sections. The sightings provided by division aviation can confirm aircraft identifications and detect aircraft that may have penetrated the FAAR coverage undetected.

V. INFORMATION AVAILABLE TO USERS

Having looked at the information required by the SHORAD fire units and the potential value of the air defense information available to Reliable STING, the effectiveness of providing this information to the user can be assessed. That assessment is made in this chapter in terms of the information made available to the users. Under the Reliable STING concept, the ABMOC communicates three types of information to SHORAD fire units. This information is transmitted over the Division Air Defense Emergency Warning (DADEW) net.

A. DIVISION AIR DEFENSE EARLY WARNING

1. Present Early Warning System

The division's methods of disseminating air defense information are changing as the Army adopts the Manual SHORAD Control System. The previous system utilized air defense command and control channels to transmit externally and internally generated command and control information (see Figure 11).

While the air defense information identified above was processed in a centralized manner, control of short-range early warning information was decentralized. FAAR sections were positioned where they could best support deployed SHORAD fire units. These sections transmitted RFDL or VHF/FM voice to the fire unit TADDS devices. Up to eight sections could operate simultaneously, each supporting a different group of users (see Figure 12).

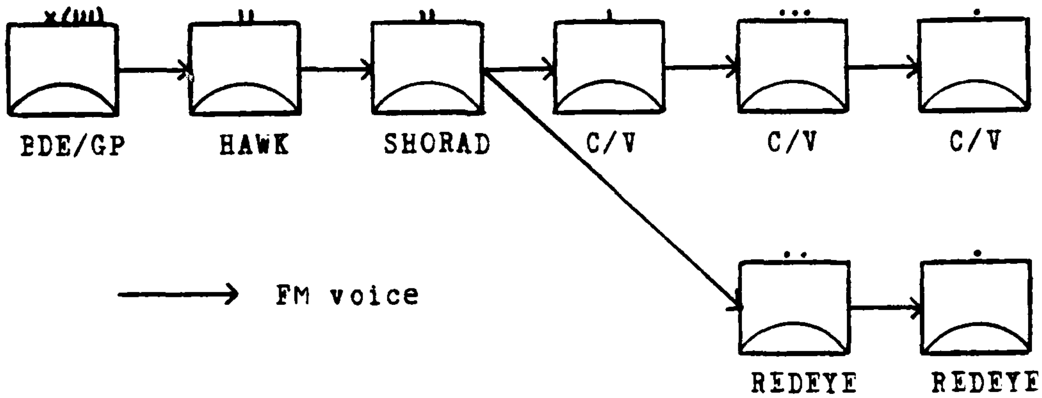


Figure 11. Longe-Range Early Warning and Command and Control Before MSCS

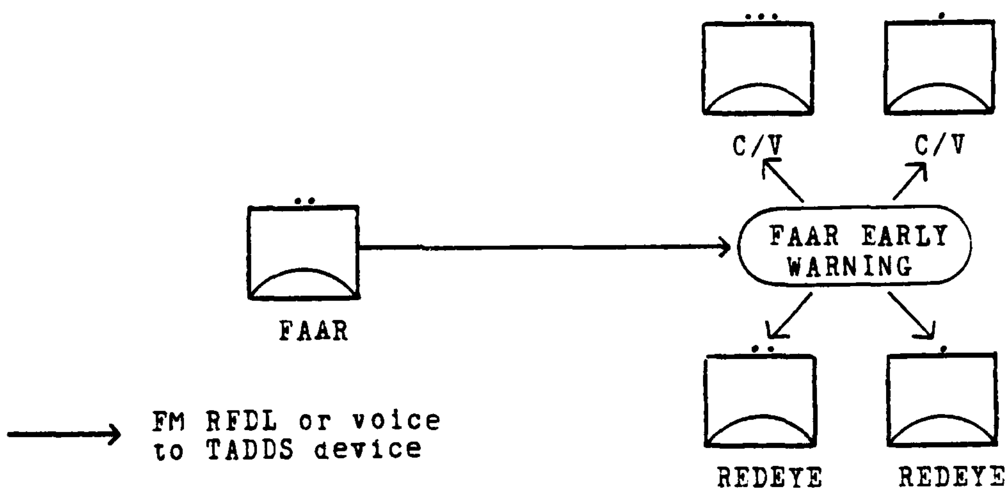


Figure 12. Flow of Short-Renge Early Warning Information

The procedures instituted by MSCS will continue to utilize the same channels for the transmission of internal command and control and short-range early warning information. This system will, however, alter the flow of information received from outside sources (see Figure 13). The air defense coordination section transmits this information from the DS Hawk battalion to the SHORAD battalion TOC, as before. The TOC retransmits this air defense information on their early warning broadcast net. FAAR sections, batteries, and others monitor this net. The FAAR sections rebroadcast pertinent elements to those units monitoring the FAAR early warning nets. The command channels between batteries, platoons/sections, and squads/teams are available as an alternate means of transmission when early warning nets are not operational.

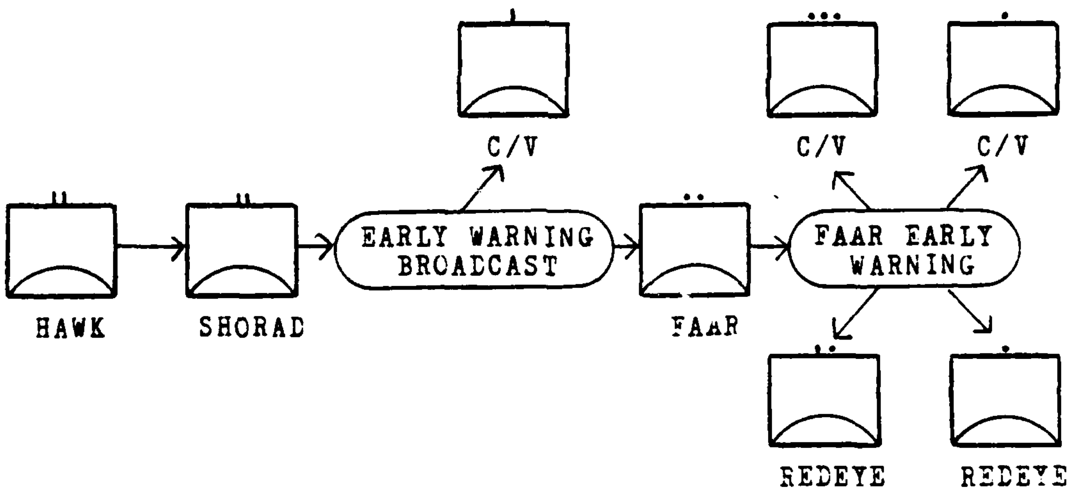


Figure 13. MSCS Network Structure

2. Reliable STING Network Structure

The implementation of MSCS procedures does not alter the basic network structure. The system still provides decentralized processing of short-range early warning and centralized processing of the other elements of air defense information. The procedures implemented by the Reliable STING concept do change this structure. Under Reliable STING the processing of all air defense information centralized except for command and control information internal to the SHORAD battalion. Both long and short-range track reports and command and control information from the regional air defense commander are transmitted to the ABMOC. The ABMOC then transmits this information to all users (see Figure 14).

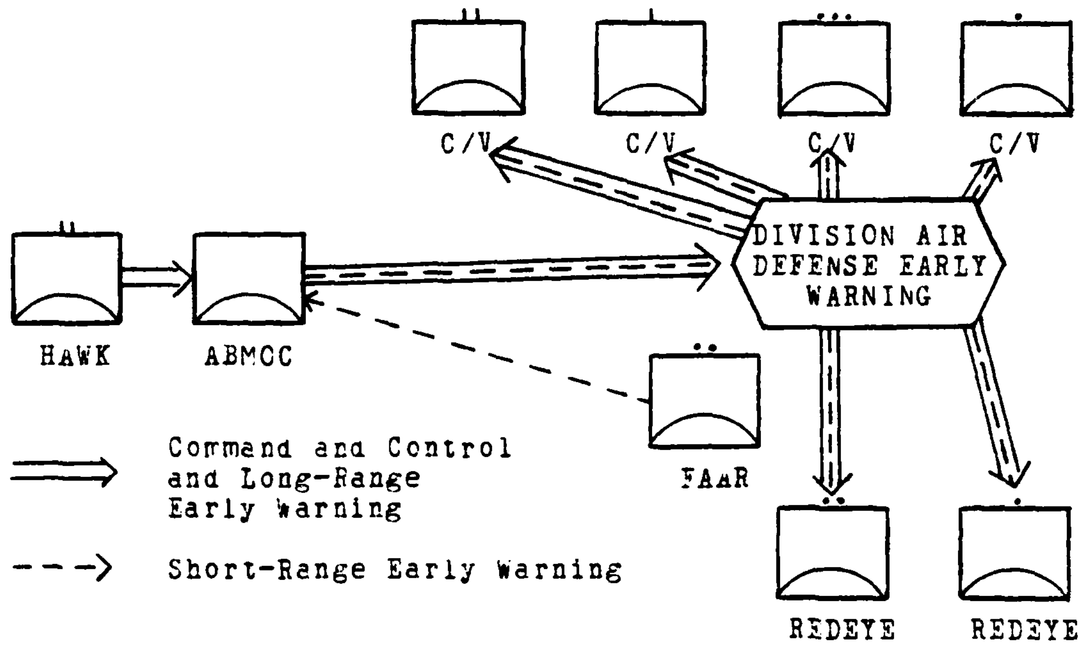


Figure 14. Reliable STING Network Structure

B. AIR DEFENSE COMMAND AND CONTROL INFORMATION

One of the aims of both Reliable STING and MSCS is to take the regional air defense commander's rules of engagement and air defense warning information and transmit them to the users via the most direct route. Reliable STING communicates this information directly to each user monitoring the DADEW net. This action, combined with the broadcasting of long-range track reports, was designed to reduce the time required for dissemination of information. This is an important point. Although some of the external command and control information is not time critical (reports are often transmitted in advance of implementation time), there are instances when these reports must get to the user as quickly as possible.

While the users do receive this information faster under Reliable STING procedures, they sometimes question the source. During the REFORGER '81 comparison of Reliable STING and MSCS, some of the participants expressed concern over the lack of authentication on the DADEW net. [Ref. 10] Because the information which was broadcast on the DADEW net was intended for use at all levels, transmissions were not encripted and had not been authenticated. The ABMOC transmitted changes in the air defense warning and rules of engagement. As important as these categories of information were, it was not possible for the users to determine where the transmissions had originated.

A feedback problem also exists. These elements of information are critical to providing an effective air defense. Unfortunately, it is impossible to ensure that all the users monitor changes that are broadcast on the DADEW net. Because all transmissions are one-way, the ABMOC does not receive any feedback. The only way leaders of SHORAD units can be assured that their subordinates have received this information is to communicate with them. As a result, these transmissions are placed back on the command nets or the superiors are forced to assume that the orders were received.

TABLE VIII

Command and Control Information Provided by Reliable STING

ELEMENT	REQUIRED FOR MINIMUM EFFECTIVE PERFORMANCE	INFORMATION PROVIDED	REQUIRED FOR OPTIMUM PERFORMANCE
MISSION	X	XX	X
HOST. CRIT.	X	X	X
WEAP. STATUS	X	X	X
FIRE DIST.	X	XX	X
AD WARNING	X	X	X
ST. OF ALERT.	X	XX	X

X - Information provided

XX - Provided by SHORAD chain of command

The air defense information provided by the ABMOC satisfies the users' needs for hostile criteria, basic weapons control status, and air defense warnings. The other elements of information, identified as essential to producing minimum effective performance, are received from the SHORAD chain of command (see Table VIII).

C. TRACK REPORTS

The track reports which are transmitted by the ABMOC are basically the same as those received from the FAAR and ADCS. Any differences are the result of processing performed within the ABMOC. The new track may have an improved identification. A tentative heading is supplied by the ABMOC. The third difference is that the information received from the ABMOC will be older, less accurate.

1. Accuracy

The users monitoring the DADEW net are not aware that it is highly likely that reports have been in the ABMOC for more than 20 sec. They are also not aware of the impact this delay has on the accuracy of aircraft location and heading information. Assuming that the determined heading is accurate to +/-22.5 deg (see Figure 15) and that the tracks are plotted without error in the ABMOC, the effect of processing and reporting delays on the accuracy of location information is discussed below.

The ABMOC announces three different types of track reports: initial, update, and scrub reports. The last is transmitted whenever it is determined that a track will no longer be reported (outbound, lost, etc.). A representative sample of tracks from the REFORGER '81 comparison were found to have required an average of 26.0 sec for processing and

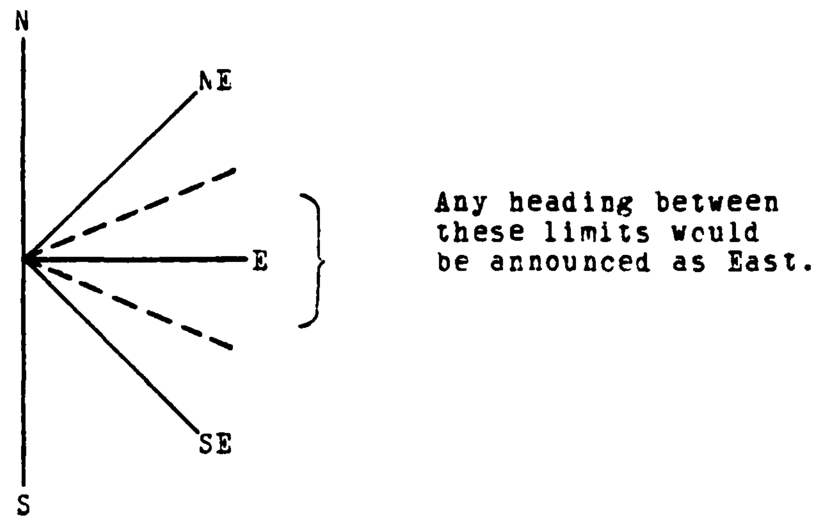


Figure 15. Accuracy of Heading Information

dissemination. [Ref. 11] This figure is somewhat deceiving because the processing and dissemination times for scrub reports were included. The processing and dissemination times for scrub reports were much shorter, but fire units are not required to detect scrubs. The average time for initial and update reports would increase to at least 31.6 sec. The effect of this 31.6 sec delay is analyzed in Figure 16 in terms of the relationship between speed and distance. A typical aircraft ingressing into the division airspace flying 400 knots, travels over 6.7 km while these actions are taking place. After this amount of time, even a helicopter flying at 85 knots will have flown more than 1.4 km. While this appears to be a great deal of degradation in accuracy, another point must also be realized. The average time of 31.6 sec does not include the transmission time required for FAAR reporting. When the assumed FAAR transmission time of 5 sec is added to the time required for ABMOC processing and dissemination, the average delay increases to 36.6 sec. Now the 400 knot aircraft has had sufficient time to travel nearly 7.8 km, effectively increasing the search sector to +/-77.2 deg.

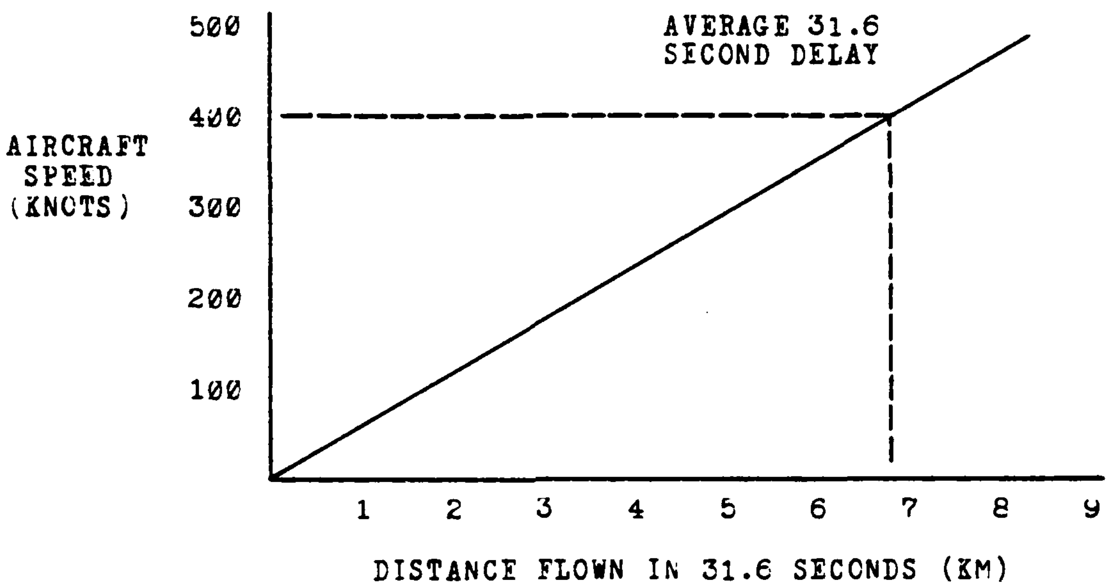


Figure 16. Distances Flown During ABMOC Processing

2. Saturation Level

Track handling rate is also a problem on the DADEW net. The sample track reports, on an average, required at least 6.4 sec to transmit. Without the scrub reports, which require approximately 2 sec to transmit, this average increases to over 8 sec. With an 8 sec report interval, only 7-8 tracks can be announced per minute.

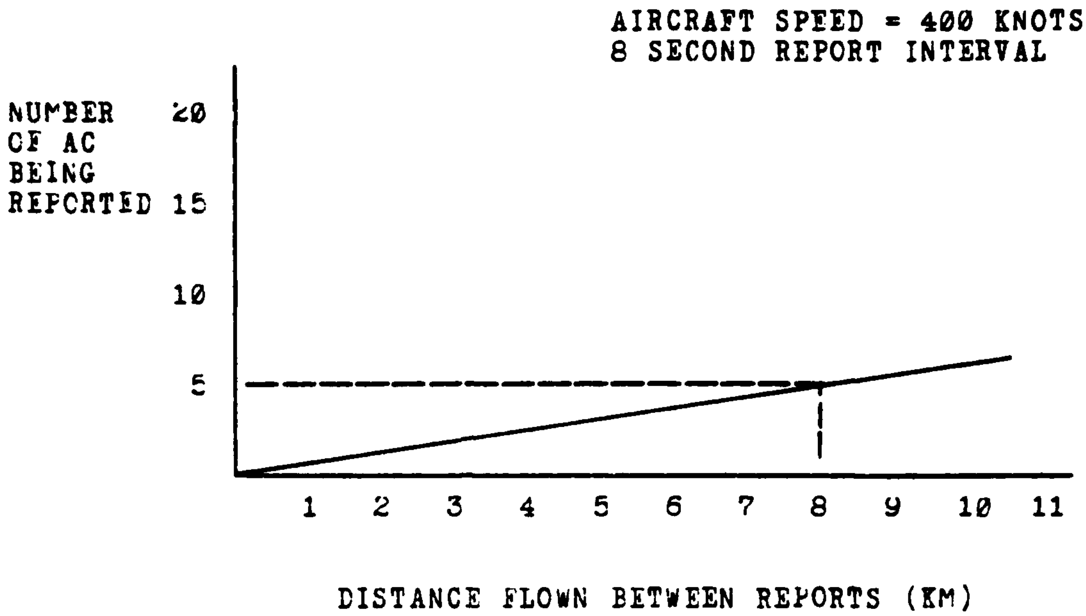


Figure 17. Distance Flown Between Successive ABMOC Track Updates

Figure 17 demonstrates the relationship between speed, distance, and the number of tracks being processed. An assumption is made that the Teller cycles between tracks, regularly updating all of them. The figure illustrates that high performance aircraft may travel as far as 8 km between updates when as few as five are being reported. REFORGER '81 test team reported that the effectiveness of ABMOC operations did not suffer as a result of saturation. [Ref. 12] The load was not so great that the plotters could not keep up and the Teller was able to continue transmitting track reports to the users. Figure 17 points out that the saturation level (capacity) of the system should be based on the value of information transmitted to the user. That is, saturation is a measure to be made external to the ABMOC, at the user level.

In the analysis of the REFORGER '81 test it was determined that the most significant feature of Reliable STING was its ability to pinpoint aircraft locations. Also, the rate of correlation between early warning and actual sightings was quite high. [Ref. 13] It is questionable though, that a system can in fact "pinpoint" a high performance aircraft if that aircraft has travelled over 7.8 km from radar detection to fire unit notification? How can fire units capable of detecting out to 8 km find aircraft that are 7.8 km from were they are reported? It is possible that some of these aircraft were detected in advance of early warning and others were detected in spite of early warning.

3. Impact on Information Value

The main question is, how do the problems of delay and track handling rate, created by system processing, affect the value of the location information? It is important to place these problems into perspective. Assuming that an aircraft is maintaining a constant heading and speed, Figure 18 illustrates the impact of each of these two factors. The arcs represent the possible location of the aircraft as the report reaches the fire unit. Because only eight directions are used, the aircraft may fly along a heading that is +/-22.5 deg either side of the reported heading. The distances between successive arcs demonstrate the effect of the handling rate. The distance between the apex and the arc represents the distance flown between detection by the FAAR and track report receipt by the fire unit.

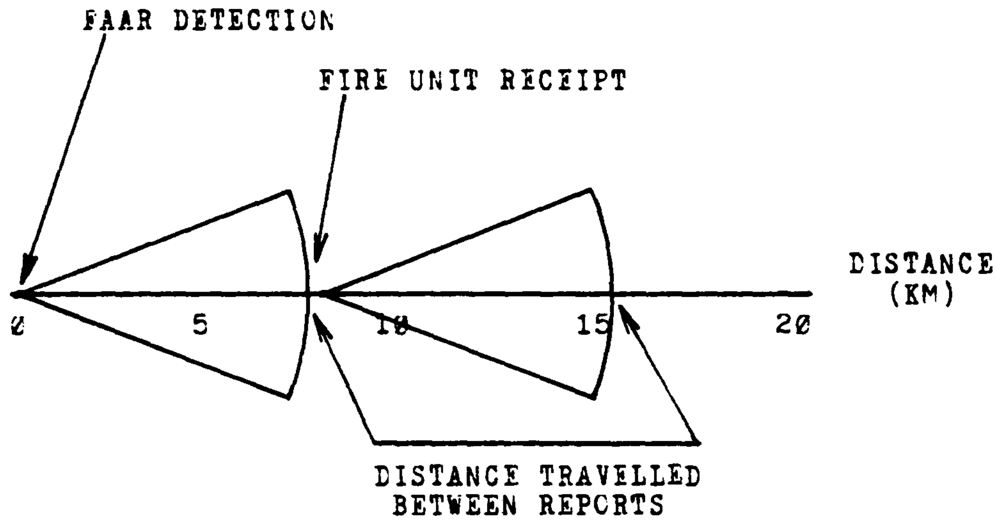


Figure 18. Example of Delay and Track Handling Rate Impact

The distance that an aircraft travels between radar detection and fire unit receipt of the track report is the most critical of the problems identified above. The results from the REFORGER '81 test indicate that fire units would receive target locations with errors as large as their maximum detection range. This is acceptable for long-range early warning, in that the crews are still alerted. However, the location of fast moving aircraft cannot be "pinpointed" in this manner. If cueing information tells the observer where to look to see the target, the target must be within his maximum detection range and search sector. If this is not the case, the location is only alerting information. If the aircraft is within the detection range, the observer will not detect it with the help of this inaccurate cueing information (see Figure 19). Regardless of flight path, if the observer detects and kills this aircraft between points 1 and 2, it is due to the fact that he was alerted by earlier reports. And if he kills the aircraft after point 2 (receipt of report) it is because this track report alerted him; it certainly did not tell him where to look.

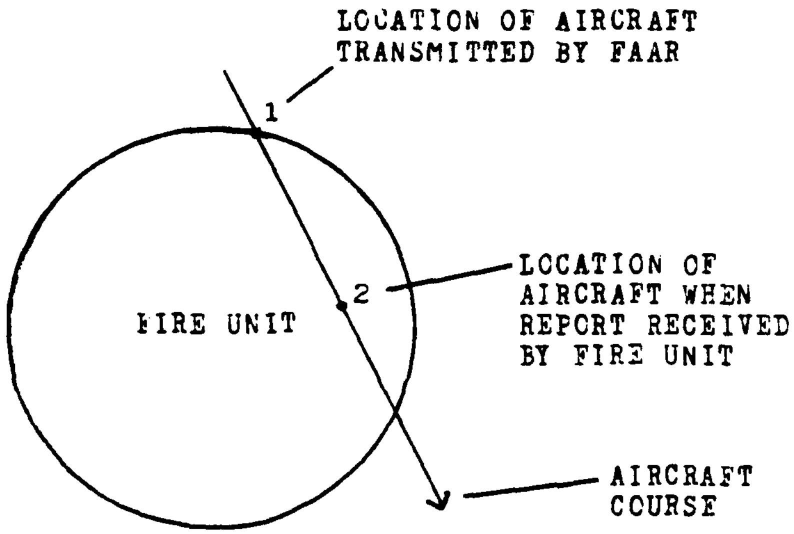


Figure 19. Example of Late Cueing Information

The track handling rate also impacts upon this cueing vs alerting question. The lower the average track handling rate, the farther aircraft travel between reports. As aircraft fly farther between reports, the number of times they are reported within fire unit detection limits decreases. Even if the locations provided by Reliable STING were accurate, smaller numbers of fire units would be able to take advantage of this precise information and its cueing value would be reduced.

The value of the announced heading also decreases as the rate declines. Flight path plots are based upon discrete observations, which can be misleading. The +/-22.5 deg initial reporting accuracy, combined with the inaccuracies produced by looking back at these discrete samples, causes the value of heading information at a fire unit to be quite low.

Table IX identifies all of the air defense information available to the users. All of the elements of target information required for performance minimum effective levels are provided by the ABMOC. With the exception of location, target information provided by the ABMOC can improve this level of performance. Because the assignment of primary target lines establishes a +/-45 deg search sector for the gunner, location information disseminated by the ABMOC can degrade performance. The sector size necessary to detect the target is based upon the 400 knot aircraft electronically detected 8 km from the fire unit, with a total reporting delay of 36.6 sec. Identification is the result of the FAAR's IFF and ABMOC coordination. Heading is now available. Aircraft type/speed and the raid size are transmitted as received by the ABMOC.

TABLE IX

Information Provided by Reliable STING

ELEMENT	REQUIRED FOR MINIMUM EFFECTIVE PERFORMANCE	INFORMATION PROVIDED	REQUIRED FOR OPTIMUM PERFORMANCE
MISSION	X	X	X
HOST. CRIT.	X	X	X
WEAP. STATUS	X	X	X
FIRE DIST.	X	X	X
AD WARNING	X	X	X
ST. OF ALERT.	X	X	X
LOCATION	(+/-45)*	X(+/-77.2)	X(+/-1)
IDENTIFICATION		X(IFF+COORD.)	X(ACTUAL)
HEADING		X(LOOK BACK)	X(ACTUAL)
AIRCRAFT TYPE		X(FAST/SLOW)	X(ACTUAL)
RAID SIZE		X(RELATIVE)	X(ACTUAL)
AIRCRAFT SPEED		X(FAST/SLOW)	X(ACTUAL)

X - Information provided

* - A result of PTL assignment
(Sector size in degrees)

VI. SYSTEM PERFORMANCE: UTILIZATION OF INFORMATION POTENTIAL

The effectiveness of any information system can be determined by analyzing how well it utilizes the potential value of available information. To ascertain the level of support Reliable STING provides to the SHORAD fire units, the air defense information provided to these users must be compared to the information received by the system. Significant differences can then be identified. The processing performed within the system must then be examined to determine the cause of improvements or degradations. Once this has been accomplished, alternatives can be proposed which take advantage of the system's strong points while addressing its deficiencies.

A. INPUT/OUTPUT COMPARISON

Comparing the information that is available to the system, to that provided by the system, is basically a comparison of the inputs and outputs. In some cases, ABMOC processing increases the value of the information. In other instances, the information remains unchanged or its value is even degraded. The elements of information that enter the system have a given resource value. This value will be identified as r. The information that is provided to the users also has a value: R. The ratio of R/r is a function of the processing procedure and the time required to complete that processing. If the ratio equals 1.0, the information value was unchanged by the processing. Greater than 1.0 represents an increase in value, while less than 1.0 identifies a degradation.

1. Unaffected Categories

Any category of information that is neither improved upon nor degraded by ABMOC processing consists of information whose value is not time sensitive or is not enhanced by coordination. The regional air defense commander's rules of engagement and air defense warning are examples of such information (see Figure 22). Because rules of engagement and air defense warnings are often transmitted in advance of implementation time and the amount of delay delay imposed by the ABMOC is minimal. This information is complete, therefore it should not be expected to be altered by processing.

Raid size, aircraft speed, and aircraft type are also unaffected by system processing (see Figure 20). The number of aircraft reported on the DADEW net is the same as that received from the sources: ONE, FEW, or MANY. No attempt is made to determine a precise count. Aircraft speed and type are really conveyed as one piece of information, which is aircraft type. As with raid size, this information travels the length of the system unchanged.

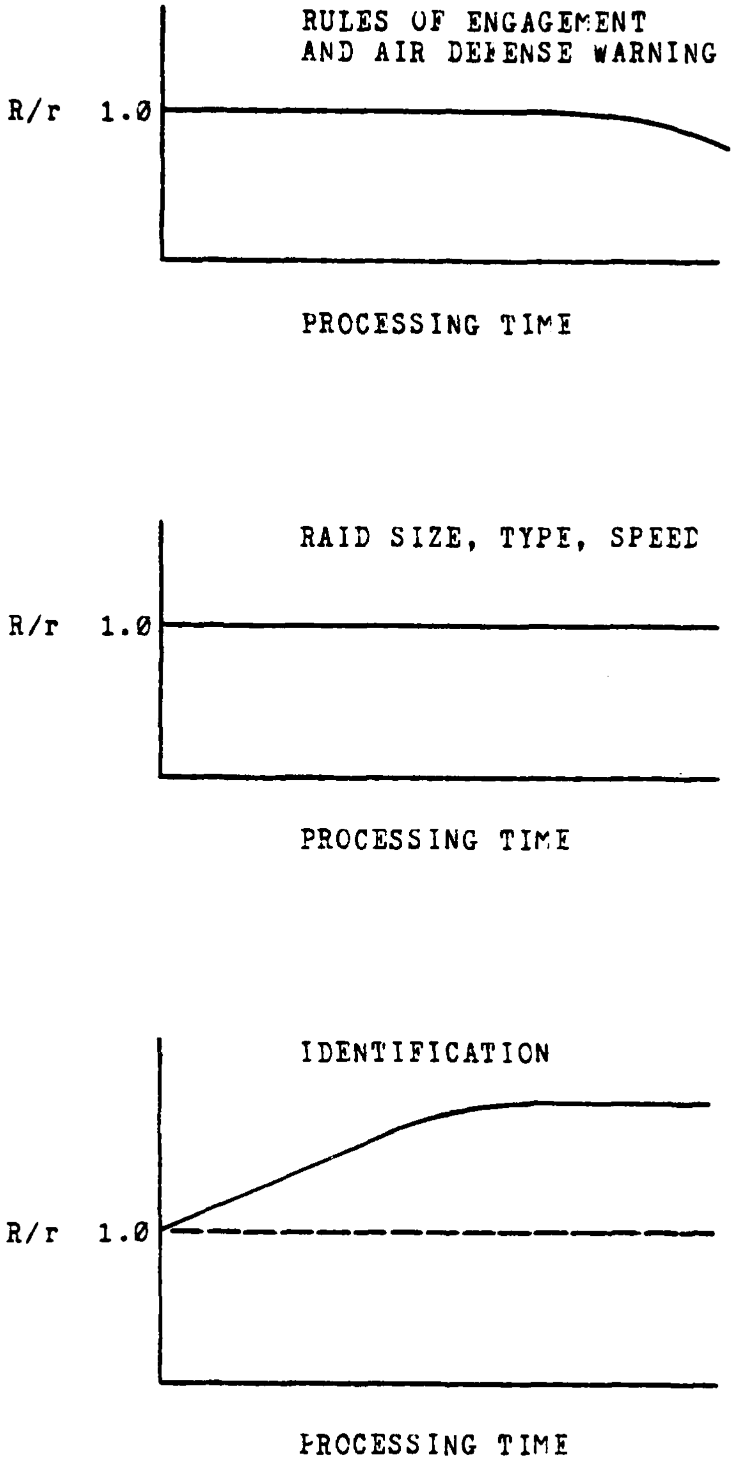


Figure 20. Information Value Verses Processing: Unaffected or Improved

2. <u>Enhanced Information</u>

The value of identification information improves as a result of ABMOC processing (see Figure 20). Remote sensors transmit identification as: UNKNOWN, FRIENDLY, or HOSTILE. For example, any aircraft that does not correctly respond to the FAAR operator's interrogation is identified as unknown (a visual sighting or special hostile criterion would be required for him to identify an aircraft as hostile). An incorrect response to the IFF challenge does not ensure that the aircraft is hostile. A large percentage of tracks reported to the ABMOC will be identified as UNKNOWN. One major benefit of the system's processing is the reduction of uncertainty about the unknown tracks. The fire units benefit from this improvement in information value. Through the receipt of improved identification, the fire unit can concentrate its efforts on aircraft that are suspected to be hostile.

3. <u>Reliable STING Degradation</u>

System processing can also degrade the value of some elements of information (see Figure 21). One category in which this occurs is aircraft location. This information, the most critical element of target information, is extremely time sensitive. As demonstrated in Chapter V, comparatively small time delays can drastically decrease the accuracy of location information. The example of the 400

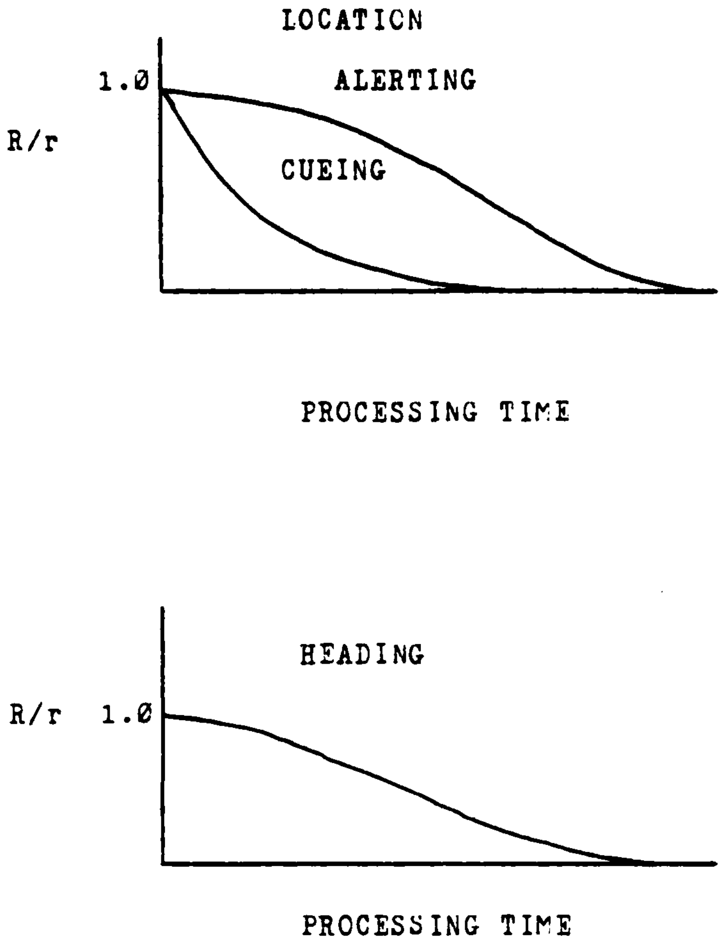


Figure 21. Information Value verses Processing: Degradation

knot aircraft illustrates that the necessary search sector required for detection grew from +/-11.3 deg to +/-77.2 deg, as a result of processing and reporting deleys. This is a significant degradation. A 22 deg search sector is accurate cueing information. A 150 deg sector is not much better than determining that the enemy is expected to attack from his side of the FEBA.

System processing also has a negative impact upon heading information (see Figure 21). Although heading is not as sensitive as location information, long reporting delays can degrade these course approximations. This problem is compounded when aircraft are making frequent course corrections to take advantage of masking terrain and to confuse air defense elements.

B. RELIABLE STING PROCESSING

The examination of system processing will concentrate on those categories of information which are impacted by processing; primarily identification, location, and heading. Any proposed alternatives should take advantage of the system's ability to improve the value of identification, while attempting to reduce the degradation of location and heading information.

1. System Processing

The ABMOC is not the only node in the system that performs processing functions. The air defense coordination section, the FAAR sections, and the fire units also process track reports. The time required for the processing actions performed by these elements is not significant when compared to the time required for ABMOC processing.

The coordinate transformation/interface provided by the coordination section does not significantly affect the value of target location information. The long-range, less accurate nature of this alerting information causes the impact to be relatively minor. This is not the case with the FAAR sections. Because the FAAR sections are providing short-range early warning, the impact of their processing can be greater than that of the coordination section, even though it requires less time to complete. The operator is not only required to transmit track data; he must also interrogate aircraft, assign track numbers, and follow these aircraft, reporting by track number. These procedures require a great deal of time, affecting the accuracy of the location information he provides to the ABMOC. The track handling rate is also degraded as a result of performing these functions. As the FAAR operator's handling rate decreases and aircraft fly farther between reports, the heading determined by the ABMOC becomes less accurate.

Members of the fire unit crew are also required to process track information. Since all track reports are announced over a single division air defense early warning net, individuals monitoring this channel must determine which reports apply to their unit. This is a filtering process that can be performed by plotting the track reports to determine if they fall within the unit's area of concern or by remembering which grid squares border this area and listening for reports in those squares. Additional time is required to complete this process, but it is offset by not encouraging observers to try and detect every aircraft reported, even those well beyond the limits of their eyesight.

2. ABMOC Processing

In order to eliminate the delays caused by ABMOC processing, it is necessary to understand how that processing is performed. Eight individuals per shift (sixteen in total) are required to perform this function (see Figure 4). More than half of this crew is employed in plotting the track reports. They monitor communications from the four FAAR sections and from AWACS or the coordination section. Each plotter receives track reports from his sensor and plots the information backwards on the long-range or main plotting boards. Each initial report includes the track designator supplied by the source. Subsequent updates also contain this number, allowing the plotter to connect the points to approximate the flight path.

The officer-in-charge (OIC) and the Teller monitor the air battle from their positions on the opposite side of the plotting boards. The OIC analyzes the long-range early warning to assist him in the management of his FAAR coverage. Both he and the Teller attempt to correlate actions identified on the long-range and main plotting boards with the aviation utilization and control information represented on the friendly aviation board. The Teller also announces these track reports over the DADEW net. The actions described above produce approximately 23 sec of the

31.6 sec average processing and dissemination time. If the accuracy of the output is to increase, this delay must be significantly reduced. Efforts directed at reducing this processing delay must be balanced against the increased value of identification information which results from this processing.

Information concerning friendly air activity, which is portrayed on the friendly aviation board, is received during coordination with the DAME. The route structure to be used by friendly aircraft, preplanned air operations, IFF zones, and other coordination information is used by the OIC and the Teller to improve upon the identification of unknown tracks. Aircraft adhering to a predetermined route structure may be tentatively identified as friendly, while those ignoring friendly coordination measures are suspected hostile. Immediate coordination can also be effected with the FCC for additional information concerning ongoing missions.

As an initial track is received from one of the FAAR sections, it is plotted and the Teller is alerted to this new track. If the tentative identification is UNKNOWN, the Teller will announce the track, but he will also observe it and try to compare its flight path to the flight information displayed on the friendly aviation board. This requires observing a few subsequent plots to determine an approximate heading.

3. Summary

The processing described above produces both positive and negative results. Any improvement in target identification can help prepare fire units for engagements and help protect friendly aircraft from attack by SHORAD assets. On the other hand, this processing and the general plotting/telling actions delay the reporting of tracks to the fire units.

It has been shown that the degradation of location and heading information is a result of slow input/output and plotting procedures. At the same time, it must be noted that coordination performed by the ABMOC is essential to improving identification. Some method of displaying tracks is also necessary to support this coordination process.

C. PROPOSED ALTERNATIVES

Before considering alternatives, the question must be ask, "Is it required that Reliable STING utilize the full potential of available information?" If it can be acknowledged that locations transmitted by the ABMOC are not accurate enough to cue fire units, a 10 km grid designation rather than a 1 km report might be utilized. Thus the system would provide only alerting information to the SHORAD fire units. With the ABMOC CIC controlling the FAAR employment and integrating short and long-range early warning information, Reliable STING is capable of providing excellent alerting coverage of the division.

The logical answer to the above question is "yes". The system should maximize the value of available information. In addition to consolidating information, coordination with airspace management elements, and providing early warning to the entire division, the system should take advantage of FAAR/SHORAD Grid accuracy. Improvement can be realized through the modification of existing procedures, alteration of the network structure, automation, or a combination of these.

1. Modification of Procedures

In the area of procedural changes, there is very little that can be done to streamline the system. The current procedures practiced by the ABMOC crew are the result of an evolutionary development process. The designers of this system have varied their procedures to minimize processing delay, while continuing to report each of the elements of target information. However, realizing that the main goal is to get accurate track information to the fire unit as quickly as possible, some improvement can be achieved by changing the reporting procedures.

Using the list of prioritized information requirements identified in Chapter III (see Table IV), track report lengths could be shortened by removing items of low priority. Location and identification are the most important elements of target information, and they should be included in every report. Announcing only location and aircraft identification (including track designator) would essentially cut the transmission times in half. Unfortunately, this action would save only 6-8 sec, a small portion of the total delay.

Therefore, procedural changes offer little potential for improvement in speed if the advantages of coordination are to be retained. Even with a drastic cut in message length, the ABMOC processing time does not significantly change. The processing functions identified above must still be performed. Therefore, an order of magnitude reduction in total delay time could not be achieved.

2. Network Structure

In contrast to procedural changes, substantial cuts in delay time can be achieved through structural changes in the underlying information network. The most obvious is to stop sending information to the ABMOC before it can be transmitted to nearby users! Track reports with accurate location and questionable identification are received by the ABMOC and track reports with improved identification and inaccurate location are transmitted over the DADEW net to the users.

A significant point that seems to be overlooked by supporters of Reliable STING is that fire units cannot take advantage of cueing information provided by the system unless they are positioned within or near the coverage of a FAAR section (see Figure 22). Only Fire Unit A can receive location cueing information. As determined in Chapter IV, the FAAR sections are the only sources of accurate cueing information. To Fire Unit B, not under the FAAR umbrella, this same track report is only alerting information. Aircraft must be accurately located within the fire unit's detection range to take full advantage of this information.

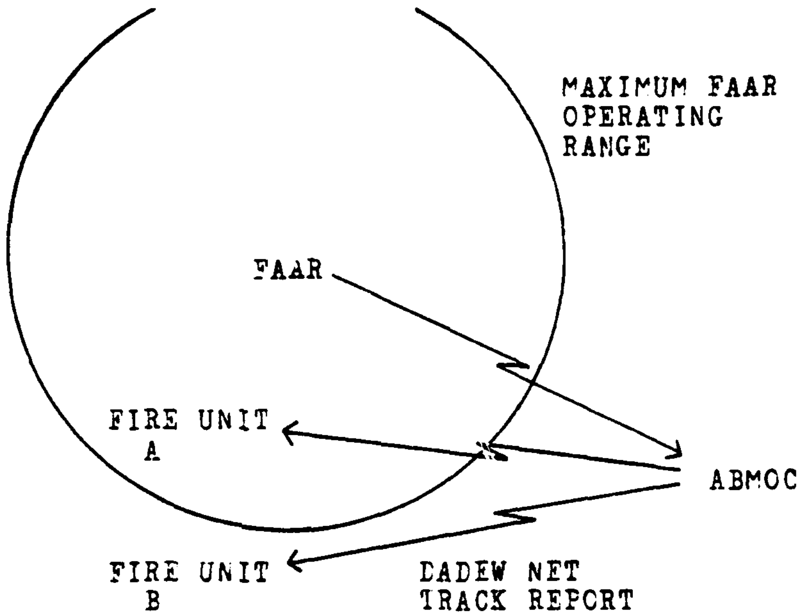


Figure 22. Fire Unit Reliance on FAAR

One of the goals of the system's designers was to do away with the fire unit's reliance upon a single FAAR section. They feel that they have succeeded. Alerting information from a wide range of sources is made available to the fire unit. However, the fire unit must still depend (indirectly) on the nearest FAAR section for accurate location information. If the user is positioned near the FAAR section, why take accurate position data and send it to the ABMCC so that it can be returned, after a processing delay, as inaccurate information?

By changing the control of information to a combination of decentralized and centralized, the benefits of ABMOC processing and the accuracy of the FAAR could both be utilized (see Figure 23). It is possible for FAAR operators to communicate both to surrounding fire units and to the ABMOC. This procedure may require the use of the section's sec radio or a different antenna configuration. The advantages are well worth the trade-off. Track reports transmitted to the ABMCC could be processed to provide alerting information to elements located throughout the division and target identification can be improved. At the same time, the fire units near the FAAR section would receive reports 5 sec old instead of 36.6 sec.

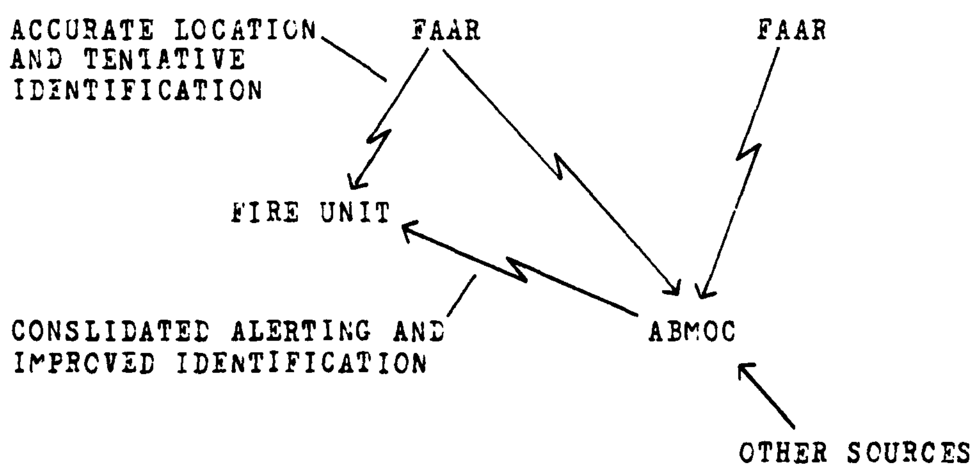


Figure 23. Decentralized/Centralized Information Control

To take advantage of this approach, the fire unit would be required to monitor both the DADEW net and a local FAAR net. The best combination would be to use the HF/AM radios, planned for IMSCS, for DADEW reports and the VHF/FM radios or TADDS receivers for the FAAR net. The most accurate location information would be available on the FAAR net, along with a tentative identification. The DADEW net would provide alerting information beyond the coverage of the local FAAR, command and control information, and emergency alert information.

The MSCS procedures are similar to this approach. Long-range early warning and command and control information are transmitted to the FAAR sections. The FAAR operators include these reports with their short-range early warning. While this approach only requires the fire unit to monitor one early warning radio frequency, it places a greater burden upon the FAAR operator. Since he is the only source of accurate location information, his processing load should not be increased.

The MSCS procedures also cannot take advantage of coordination with the DAME and FCC unless flight coordination information is passed down to the FAAR sections. Again the processing load would limit the effectiveness of the sections.

3. Automation

The third alternative to standard Reliable STING operations would reduce time delays by automating some of the processing and reporting procedures. Recent developments in size reduction and performance enhancement of microcomputers offer a technology that is presently available at a relatively low cost. An example of the application of this technology is the Theater Target Analysis and Planning (TAP) system. [Ref. 14] Using commercially available "desk-top" computers and peripheral devices, the Defense Nuclear Agency developed TAP to assist nuclear fire planners in the corps TOC. This type of approach is important because one of the goals of this thesis was to avoid rewriting the requirements for the automated SHORAD-C2 system.

For the purposes of automation, it is again important to remember the objectives that should be promoted. From the users' point of view, the primary goal is to present accurate and timely information to the fire unit. The ABMCC's ability to provide improved identification through coordination with the DAME/FCC and produce consolidated alerting information are also important characteristics that must be retained.

Automation of Reliable STING should not be a pure approach, but combined with procedural and structural changes. Only by reducing the amount of processing and

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minimizing human participation can the time delays be significantly reduced. Some human participation will always be required: the user's. With him in mind, one must determine:

o The method of filtering out pertinent information.

o The method of communicating this air defense information.

The examination of Reliable STING processing revealed that use of a single broadcast net requires the users to process track reports to see if they are pertinent. By applying the suggested structural change, this filtering process can be reduced. If the fire unit receives track reports from a nearby FAAR section (one whose umbrella extendes over the unit's operating area) there is a greater probability that these reports are important to the unit.

A second point that must be established is the means by which the fire unit will receive air defense information. Units can receive information communicated by voice, graphics device, or text display. Under MSCS a graphics display (TADDS) is used and Reliable STING communicates by voice over the DADEW net. The Army presently owns over 2500 TADDS devices which only provide location to the nearest 5 km. At the same time, the standard FAAR is capable of transmitting locations (RFDL) to the nearest 1 km. A quick comparison points out that FAAR/RFDL is as accurate as Reliable STING and that perhaps something should be done to improve the TADDS device.

There are factors that support improvement of the TADDS system. As mentioned above, they are already in the Army inventory. The system also has a built-in VHF/FM receiver. Any new device would require this capability or would have to be operated with a tactical FM radio. With this in mind, the possibility of adding some limited logic capability to the TADDS system should be explored. A microprocessor capable of performing the following functions would greatly enhance the device's capabilities:

- o Allow the user to change the reference scale from 5 km to 1 km.
- o Transform the display from sensor centered to weapons centered or weapons offset. This would include permitting the user to enter his location and that of the FAAR.
- o Provide limited memory to store the last few FAAR transmissions.

These functions could be accomplished with less processing power than that available in an advanced hand calculator.

By allowing the user to choose the presentation scale, the device could be used to provide alerting information out to 15 km. As targets would approach the fire unit, the scale could be changed to take advantage of the sensors accuracy. At this point the device would represent a 7-by-7 km square instead of the standard 35-by-35 km. To make this change effective, an offset user position may be necessary. By positioning an observer along an edge of the display, at least 5-7 km of display would be projected towards attacking aircraft (see Figure 24). The other alternative is to position the user in the center of the device. While employing a 1 km scale, this would project at least 3 km in all directions.

A memory capable of storing the last few FAAR transmissions would also be required. This would allow the user to change scales without losing the latest track data.

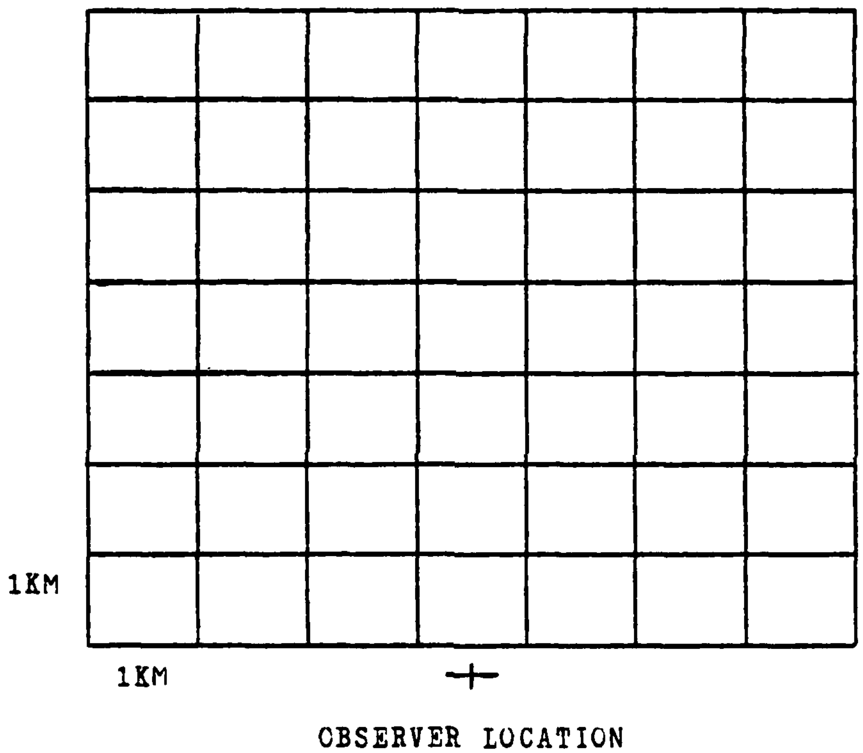

Figure 24. Reconfigured TADDS Device

When the FAAR operator transmits a SYMBOL ALL CLEAR message, this memory could also be cleared. Memory size would depend upon the number of tracks transmitted between clearing operations.

In addition to improving the display device, something should be done to automate the manual procedures performed by the FAAR operator. The FAAR systems in the field today require a great deal of manual participation in the transmission of track reports. The FAAR operator has the option of selecting manual or automatic IFF challenge procedures. Beyond that point the system does very little by itself. If the operator wishes to transmit the location and tentative identity of a given track, he must position a set of cross-hairs over the target projection using a joystick. Once this has been accomplished, the operator must press a button identifying the target as FRIENDLY or UNKNOWN. This action causes an RFDL signal to be transmitted to the TADDS device.

The performance of this system could be improved by the automation of three functions:

- o Transmission of target location.
- o Transmission of tentative identification.
- o Assignment of track numbers.

Once a target has been challenged by IFF, the results of the interrogation are represented on the FAAR CRT display. This information is transmitted by the Receiving System to the Display System. [Ref. 15] A microcomputer could combine this information with the target locations stored in the Data Link System to free the operator from having to manually select the identification. Since target locations are stored, a computer could access this data and cycle through the current targets automatically transmitting the latest location information. The SYMBOL ALL CLEAR signal could be periodically transmitted, as well.

In addition to location and identification, the FAAR also transmits a radar identification pattern and a separate alert signal to identify a new track (one that has not been transmitted before). With these two pieces of information, track numbers could be generated. A block of track numbers could be available in the software (1-100, for example). When a new target is detected the computer selects the next unused number and combines it with the FAAR identification to produce the aircraft track number. Inclusion of this number in FAAR transmissions would aid the ABMOC operators in their task of information correlation.

The goals of utilizing the ABMOC's ability to improve identification information and provide consolidated alerting information cannot be realized unless this target information is also transmitted to the ABMOC. If the first step in automating Reliable STING is from the FAAR to the fire units, the second should be from the FAAR to the ABMOC.

Each of the FAAR sections broadcasts on a different VHF frequency. This prevents interference between sections and allows fire units to change sensors by changing the frequency setting on the TADDS device. The fact that they operate on different frequencies also eliminates the need for the ABMOC to synchronize or otherwise control their transmissions. These transmissions could be treated as asynchronous and collected by a microcomputer acting as a concentrator.

The concentrator would have separate ports and buffer space for each of the sensors (see Figure 25). Each buffer would hold the last track report received from the FAAR section. The concentrator would access the buffers in a cyclic manner, transmitting the FAAR reports at a much higher speed to another computer, which could drive a CRT display or relay reports to the DAME, FCC, and others. These procedures could be implemented in the ABMOC without automating the FAAR. The RFDL signals initiated by the FAAR operator could also provide the inputs for this system.

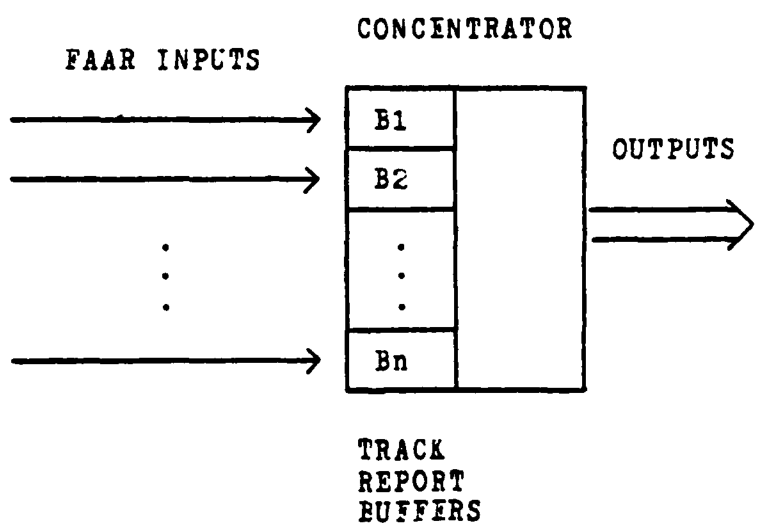

Figure 25. FAAR Concentrator

In order to perform its coordination and dissemination functions, the ABMOC requires the capability to:

o Display track data.

o Perform heading calculations, coordinate transformations, and other computations.

o Display coordination measures.

o Display friendly air defense assets and radar coverage.

o Communicate coordination information to the DAME, FCC, and ADCS.

o Disseminate early warning, command and control, and emergency alert information.

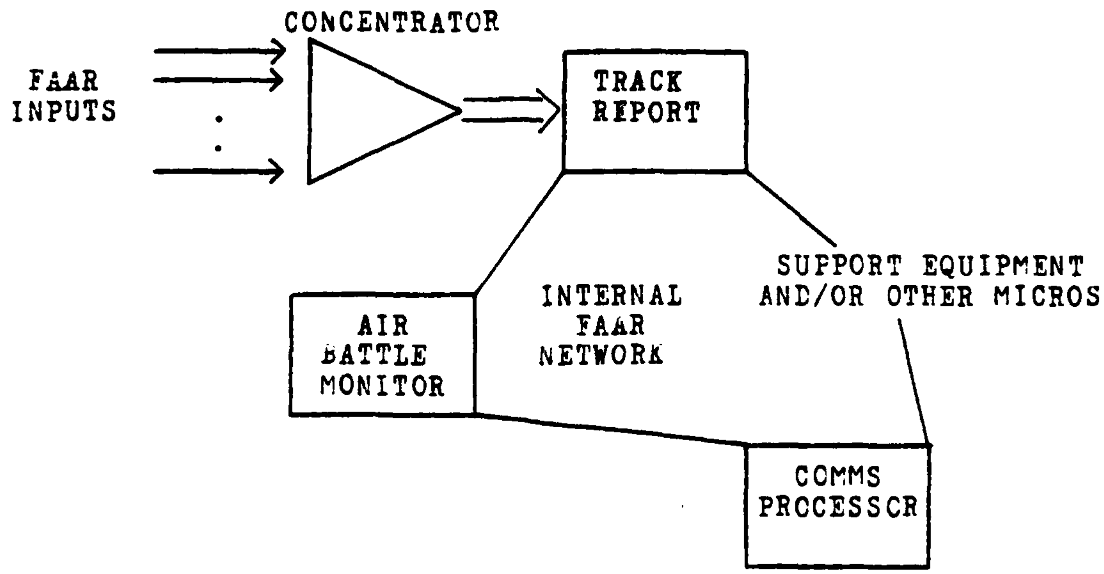

Figure 26. Automated STING Network

These functions could be performed by a group of microcomputers and their supporting equipment, connected by a high-speed local network (see figure 26). As stated above, track reports could be communicated to an "Airbattle

Monitor" station. At this station, the OIC or NCOIC could observe the tracks (long and short-range), while coordinating FAAR coverage. At a second station, perhaps the "Track Report" station, track reports would be examined and disseminated by the Teller. Unknown reports would be compared to airspace coordination measures, which could be accomplished either manually or automatically. Updates to aircraft identity would be transmitted to all the other stations.

There are other functions that could also be performed by an automated system. If track numbers were available, the system could approximate the heading in the same manner as it is computed manually. If a clock device was used to date the track reports (time of receipt), an approximate speed could also be determined. Coordinate transformations could be performed automatically.

The third step in this automation process would be to network the ABMOC, ADCS, DAME, and FCC (see Figure 26). Whereas the FAAR links would be one-way, two-way communications are required between the ABMOC and each of these stations. The majority of the traffic would, however, be originated by the ABMOC. Since these elements are not co-located, military telephone or radio links would be required to connect them. A microcomputer functioning as a communications processor could be utilized to interface between these stations and the internal ABMOC network.

To reduce the amount of processing performed by the ADCS, an attempt should be made to extract information from the automatic data links which connect the Hawk BOC to the batteries and the air defense group CP. The coordination section's computer could display the tracks passed on these links on a CRT along with the short-range tracks provided by the ABMOC. Long-range tracks that appear to threaten the division could be selected for transmission to the division. The computer's software could continue to update these tracks.

The ABMOC's consolidated alerting information, air defense command and control, and emergency alert information would be broadcast by voice to the entire division. This procedure, the same as used today, would be sufficient for alerting information. This is true, only because the FAAR would be transmitting cueing information to the fire units. These voice transmissions would also allow any divisional units to receive the information.

Target information can be transmitted to the fire unit much faster with RFDL, than by utilizing standard radio transmissions. However, an accurate display device is required to take advantage of this speed. The FAAR transmissions are also the key to enhanced effectiveness of ABMOC operations. If track report processing functions were automated and voice transmissions by the FAAR sections were continued, large reductions in delay time would not be possible. By entering RFDL signals into the system, the delays caused by the FAAR operator and the ABMOC plotters could be eliminated.

VII. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

A. SUMMARY

The SHORAD fire unit was identified as the primary user of the air defense information provided by the Reliable STING Early Warning System. When this user's information requirements were identified, the elements of information essential for minimum effective performance where also determined. Excluded from these minimums was short-range early warning information, the accuracy of which represents the difference between minimum and optimum levels of information support.

It was found that the sources of information available to Reliable STING provided the system with the necessary information to satisfy the user's requirements. Short-range early warning produced by the FAAR sections was determined to be the most accurate in terms of target location. However, this accuracy was significantly degraded while the track report was being processed. This same processing improved the value of identification information and did not affect the essential elements of information. The differences in value between the system's inputs and outputs resulted from the slow manual procedures performed by the ABMCC operators and the centralized approach to information processing.

The suggested enhancements were directed at providing greater information value by reducing the delays associated with the present concept. The determination was made that processing delays could be reduced by modifying procedures, altering the underlying structure of the system, automating processing functions, or some combination of these three approaches.

B. CONCLUSIONS

Analysis of the Reliable STING concept produced the following conclusions:

- o Reliable STING provides a framework for managing the flow of air defense information more effectively than previous SHORAD command and control procedures. Even though its manual processing is slow in terms of short-range early warning, the system is capable of providing timely transmission of long-range early warning, externally generated command and control information, and emergency alert information.

- o It is impossible for the ABMOC to provide accurate short-range early warning information. High performance aircraft fly too fast for the system to handle. The delayed track reports, transmitted by the system, provide adequate support for long-range planners and intermediate level coordinators and managers. However, the operational users (the fire units) require the potential accuracy of this short-range early-warning information to increase their level of performance above the minimum.

- o The ability of the ABMOC to improve identification information through coordination and consolidation should not be degraded. This is a valuable function that will still have to be performed when SHORAD weapons are deployed with IFF devices. The identification determined by a Stinger IFF will not be any better than that provided by FAAR or Hawk interrogation devices. This improved information would also allow fire units to concentrate their efforts on aircraft which are suspected hostile.

- Both Reliable STING and the enhanced MSCS should adopt decentralized procedures for processing short-range early warning information. Whether the systems functions are automated or remain manual, this step would greatly improve the accuracy of location and heading information provided to the fire units.

- The performance of Reliable STING could be greatly improved through automation of its information processing functions. Both the track handling rate and the total number of aircraft that could be processed would increase. At the same time, the delays imposed upon short-range early warning information would be significantly reduced.

C. RECOMMENDATIONS

The following recommendations are made:

- Reliable STING's procedures for transmission of short-range early warning should be altered. FAAR sections should broadcast track report information to surrounding fire units, in addition to their transmissions to the ABMOC.

- To maximize the effectiveness of the FAAR sections, the ABMCC OIC should ensure that these sensors are positioned to provided accurate cueing information for fire units with the most critical missions. Positioning FAAR sections to provide alerting coverage of the entire division and to supplement the coverage of Hawk sensors should not be the only considerations.

- Fire units should be provided with a device which would allow them to receive digital cueing information. Potential improvements to the TADDS device should be examined to determine possible hardware and firmware combinations that could be applied to this need.

- Automation of ABMCC functions should be explored in detail. Track receipt, processing, and coordination tasks should be analyzed to determine the configuration, size, and performance requirements for such a system. Existing systems, the Theater Target Analysis and Planning system for example, should be examined to determine if their features and configurations are applicable.

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